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# ***JPRS Report***

# **Science & Technology**

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***USSR: Materials Science***

# Science & Technology

## USSR: Materials Science

JPRS-UMS-91-005

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**Investigation of a System for Alignment With the Horizontal Component of an Electromagnetic Field**

917D0048A Sverdlovsk DEFEKTOSKOPIYA in Russian, Jul 90 pp 46-54

[Article by V. I. Redko]

UDC 620.179.18

[Abstract] A system for monitoring the alignment with the horizontal component of an electromagnetic field is studied with a view toward applications in defectoscopy and thickness-measuring devices. Expressions are derived and hodographs plotted for the EMF difference between two series-connected detector coils in the field of the generator coil on the other side of a sheet-like part. This data will enable us to design a device that keeps both generator coils and detector coils on a common axis and properly aligned without the need for a rigid mounting device between the two, which would then restrict the size of parts which could be handled. It is found that the radius of the generator coils should be as small as possible, depending on the part thickness or primary nondestructive testing pickup. A range of values are obtained for geometric parameters of the detector coils that provide maximum sensitivity. References 6 Russian; figures 8.

**Variation in Sensing Element Activity of a Halogen Leak Detector During Atmospheric Probe Tests**

917D0048B Sverdlovsk DEFEKTOSKOPIYA in Russian, Jul 90 pp 70-76

[Article by S. A. Dobrotin, S. G. Sazhin and L. A. Stolbova; Gorky Polytechnic Institute, Dzerzhinskiy Branch]

UDC 620.165.29

[Abstract] One of the drawbacks of the GTI-6 halogen leak detector is the poisoning of its sensing element that occurs during detection of the test gas, i.e., reduction of the activated thermionic current leading to reduced sensitivity. Oxygen is used to restore ("freshen") the sensitivity during a pause in monitoring activity, but too long a pause naturally lowers the number of measurements that can be made per unit time and is undesirable for use in high-output automated testing equipment. A simple rate equation is postulated to describe this variation in sensitivity, and the kinetic constants therein determined experimentally. It is determined that the freshening pause should be only 3 to 5 times as long as the monitoring period. These equations also indicate a drift in background signal which must be taken into account during output signal processing. References 8: 7 Russian, 1 Western; figures 8; tables 1.

**Raduga-5 Thermalvision Complex for Nondestructive Testing**

917D0048C Sverdlovsk DEFEKTOSKOPIYA in Russian, Jul 90 pp 76-84

[Article by G. A. Padalko, S. S. Sliva, V. K. Fomenko, D. A. Rapoport, O. N. Budadin, E. A. Mnatsakanyan, V. M. Sapsin, P. O. Skobelev and V. I. Kober]

UDC 620.179.13

[Abstract] The authors have developed the Raduga-5, a prototype thermalvision set suitable for commercial production. The device monitors the perturbing effect of known heat sources on the temperature fields at the surfaces of a part, and by solution of the inverse problem the physical characteristics within the part are deduced—the method is known as thermal tomography. The device incorporates a composite-signal color CRT, an SM-1420 computer and image processing applications programs. The device can register temperatures in the range from 0 to 252°C with a sensitivity of 0.1°C, and angular resolution of 7.2 min of arc in a 20 by 17.5 degree field of view. References 8 Russian; figures 3; tables 1.

**Ultrasound Transducer for Surface Defectoscopy**

917D0048D Sverdlovsk DEFEKTOSKOPIYA in Russian, Jul 90 pp 93-95

[Article by A. N. Annenkov, V. S. Borshchan and O. D. Sivkova; Novomoskva branch of the Moscow Chemical Engineering Institute]

UDC 620.179.16

[Abstract] A surface acoustic wave transducer is described which is based on the principle of measuring the shear in a lithium niobate piezo wafer. The device can detect very brief pulses (less than 0.5 microseconds, in the megahertz range), is resistant to spurious signals, simple to manufacture and, unlike other current such transducers, requires only a small contact area with the part (12.0 x .045 mm) thus making it useful for defectoscopy of parts with complex shapes. References 4 Russian; figures 2.

**Deformation Hardening of Heat-Resistant Materials Upon Extension**

917D0088A Kiev PROBLEMY PROCHNOSTI in Russian Sep 90 pp 21-25

[Article by V. P. Golub, L. V. Mironenko, N. V. Yashchuk; Institute of Mechanics, Ukrainian Academy of Sciences]

UDC 539.376

[Abstract] An analysis is presented of the hardening of heat-resistant materials based on their true tensile-test



diagrams, using experimental diagrams of the materials EI437B, EI827, EI867, KhN55MVTs at 20-1100°C. Tests were performed on smooth cylindrical specimens with length/diameter ratio 5/1 deformed at 0.4 mm/min. The true stresses and linear deformations can be used to estimate deformation-hardening parameters of heat-resistant materials. The transition from stable to unstable deformation hardening occurs at a threshold temperature about 60% of the melting point. Figures 5; References 8: 7 Russian, 1 Western.

### **Influence of Deformation Rate on Discontinuous Flow of Titanium Alloys Under Static Tensile Stress at 4.2 K**

917D0088B Kiev *PROBLEMY PROCHNOSTI*  
in Russian Sep 90 pp 26-30

[Article by V. A. Strizhalo, V. Yu. Bugayev, I. I. Medved; Institute of Strength Problems, Ukrainian Academy of Sciences]

UDC 539.43

[Abstract] Results are presented from an experimental study of the influence of varying deformation rate on type of discontinuous flow of structural steels and the strength and ductility characteristics of the steels. An attempt is made to establish the relationship between the nature of deformation of the material and the thermal processes occurring in the deformed volume as the deformation rate is increased in order to determine the influence of heating of the specimen on plastic instability of the materials at very low temperatures. Tests were performed under rigid static active loading at 293, 77 and 4.2 K in air, liquid nitrogen and liquid helium. Increasing the deformation rate at liquid-helium temperatures was found to change the nature of deformation of the material, stopping discontinuous flow and causing monotonic accumulation of deformation. The reason for the change in nature of deformation of the material is the increase in temperature of all or most of the gage portion of the specimen due to the heat flux generated by the plastic deformation. Figures 3; References 8: Russian.

### **Failure of Magnesium and Magnesium-Lithium Alloy VMD5 Under Shock Loading**

917D0088C Kiev *PROBLEMY PROCHNOSTI*  
in Russian Sep 90 pp 30-32

[Article by V. K. Golubev, Yu. S. Sobolev, N. A. Yukina; Moscow]

UDC 539.4

[Abstract] A study is made of the conditions of spalling failure of magnesium and the magnesium-lithium alloy VMD5 under shock loading conditions. Specimens of magnesium 10 mm thick and 40 mm in diameter were cut from a bar, specimens of VMD5 10 mm thick and 50 mm in diameter were made from a blank 8 cm thick and

15 cm in diameter. The specimens were attached to an aluminum sheet 4 or 8 mm thick and loaded by striking the sheet with an aluminum plate 4 mm thick accelerated by detonating a thin layer of plastic explosives. Longitudinal cross sections of the specimens were cut and metallographically analyzed. The loading conditions of the specimens were computed in the acoustical approximation. Failure occurred when microscopic spalling sites expanded and merged to form larger cavities, which then combined into spalling cracks. With the characteristic loading time of 1.5  $\mu$ s, total macroscopic spalling fracture in VMD5 alloy occurs at negative tensile pressures of 1.5-1.6 GPa, while spalling sites are generated at negative pressures of 0.6-0.8 GPa. Figures 2; References 3: Russian.

### **Brittle Fracture Tendency of 09G2MFB Steel Welded Joints Following Long-Term Exposure to High Temperatures**

917D0088D Kiev *PROBLEMY PROCHNOSTI*  
in Russian Sep 90 pp 35-40

[Article by V. M. Goritskiy, G. R. Shneyderov, V. M. Maslyuk, K. M. Sofronov; Central Scientific Research Institute for Design of Steel Structures imeni N. P. Melnikov]

UDC 669.018.95:539.56

[Abstract] A study is made of the influence of long-term holding at high temperatures on the brittle-fracture resistance of welded joints in 09G2MFB steel. The steel was rolled at 830-930°C to sheets 50 mm thick which were then normalized at 900-1000°C. The hot-brittleness tendency of the steel was evaluated after holding specimens in a muffle furnace for 500-1300 hours at 450°C. Impact-toughness testing was performed on transverse specimens at various temperatures. The seam-zone structure of welded joints was simulated by induction heating to 1300°C of 6x11x55 mm specimens, with cooling rate varying from 0.1 to 290°C/s. Electron microscope studies of foils and carbon replicas were performed. It was found that varying the end-of-rolling temperature between 830 and 930°C and the normalization temperature between 900 and 1000°C supported the formation of a ferrite-pearlite structure with good hot-brittleness resistance. The increase in critical brittleness temperature  $T_{50}$  following holding at 450°C did not exceed 20°C and did not result from weakening of grain boundaries. The brittle-fracture tendency of welded joints following long-term heating depends essentially on the structure of the seam zone, which depends on cooling rate. Martensite and bainite have the greatest brittle-fracture tendency. electric-slag, manual and automatic arc welding under optimal conditions, forming ferrite-pearlite structure, yielded good brittle-fracture resistance following long-term exposure to high temperatures. Figures 6; References 8: Russian.

**Study of Ceramics By Vickers Diamond Pyramid Indentations**

917D0088E Kiev *PROBLEMY PROCHNOSTI*  
in Russian Sep 90 pp 49-54

[Article by G. A. Gogotsi, A. V. Bashta; Institute of Strength Problems, Ukrainian Academy of Sciences]

UDC 621.178.15

[Abstract] Studies are performed on silicon nitride and zirconium dioxide ceramics (ceramic 1 and 2), selected as two characteristic brittle and linearly elastic materials. Studies were performed under loads of 5-600 N on surfaces polished to smoothness class 12. The test machine traverse speed was 0.05 mm/min, 6-12 indentations for each load level. The hardness characteristics and crack resistance of the surface were found to depend on the indenter load in both types of ceramic materials. A stabilization segment, a horizontal section on the curves illustrating the characteristics  $H_V/K_{IC}$ , was found in the mechanisms of deformation and failure of the ceramics. One reason for the nonlinear nature of the deformation diagrams of the materials studied is the formation of deep microcracking zones and phase transformations in the indenter imprint. A semiempirical equation is derived for calculation of the crack-resistance vector of the surface  $K_{IC}$ . Figures 5; References 26: 5 Russian, 21 Western.

**Influence of Optical SO115M Pyroceram Specimen Size on Axial Compressive Strength**

917D0088F Kiev *PROBLEMY PROCHNOSTI*  
in Russian Sep 90 pp 55-59

[Article by L. R. Gayevskaya, Yu. I. Moskvina, V. L. Stepchenko, G. M. Okhrimenko; Institute of Strength Problems, Ukrainian Academy of Sciences]

UDC 539.411:620.173.22:666.22

[Abstract] The short-term axial compressive strength of SO115M pyroceram is studied as a function of specimen size. Cylindrical rods 10, 20, 30 and 80 mm in diameter with height/diameter ratio 3 were tested. Specimens were ground smooth, with microscopic irregularity height on cylindrical and flat surfaces 0.63-1.25 mm. The ends of the specimens were epoxy glued to depressions in the metal supports of the test machine to decrease the influence of contact stresses at the points of transmission of the compressive force. It was found that the axial compressive strength of the specimens decreased with increasing dimensions of the specimens according to the statistical theory of brittle strength of Weibull. The curve of compressive strength as a function of volume, lateral and contact surface or specimen diameter can be approximated by a straight line in logarithmic coordinates with slope proportional to the power to which the lateral and contact surfaces or

diameter of the specimen must be raised in computing the volume of the specimen. Figures 3; References 10: Russian.

**Influence of Stretched Flat Metallic Inclusions on Structural Steel Toughness**

917D0088G Kiev *PROBLEMY PROCHNOSTI*  
in Russian Sep 90 pp 63-69

[Article by L. I. Gladshteyn, R. A. Miliyevskiy, I. V. Bekriyeva; Central Scientific Research Institute for Design of Steel Structures imeni M. P. Milnikov]

UDC 539.4

[Abstract] The influence of elongated platelike sulfur inclusions on viscous fracture in the transverse direction is studied on specimens of strip nickel steel containing 6.5% Ni. Steel from five laboratory 50-kg melts containing 0.004-0.042 mass percent sulfur, deoxidized with silicon and aluminum, was poured in 17 kg ingots, forged into 60x60 mm flatbars and rolled at 900-1200°C with 5x compression into 12 mm strips which were normalized as usual for this steel with heating to 900 and 790°C and tempering at 580-590°C, 1.5 hr. The toughness of the steel was judged by room-temperature tensile testing of 6 mm cylindrical specimens and dynamic bend testing of specimens with semicircular and sharp notches. All specimens were cut across the rolling direction. The mean length, frequency and shape factor of visible sulfur inclusions increased with increasing sulfur content, which corresponded to decreasing toughness. The density of traces of elongated pore cracks observed in fracture surfaces was comparable with the frequency of inclusions, but the mean crack length was greater than the mean length of inclusions by approximately a factor of 10. The impact toughness and specific total crack length were directly correlated. A model is suggested for the influence of parallel-oriented extended platelike inclusions on the maximum ductility in extension in the direction transverse to the rolling direction. These inclusions decrease ductility more rapidly than do compact inclusions, their influence increasing with increasing elongation. The effect is equivalent to an increase in deformation in the area of the extended inclusions by a factor of eight. Figures 7; References 12: 5 Russian, 7 Western.

**Installation for Determining Low-Temperature Vacuum Elasticity and Inelasticity of Materials**

917D0088H Kiev *PROBLEMY PROCHNOSTI*  
in Russian Sep 90 pp 94-97

[Article by A. F. Voytenko, Yu. F. Balandin, S. R. Shimanskiy; Institute of Strength Problems, Ukrainian Academy of Sciences]

UDC 620.179.162:539.32

[Abstract] An installation has been developed for determination of the dissipation of energy in materials under vacuum conditions at liquid nitrogen and liquid helium temperatures. The installation consists of a cryostat with internal vacuum cavity suitable for testing down to 80 K using liquid nitrogen and 10-12 K using liquid helium. A cross-sectional diagram of the installation is presented and described. The design of the installation allows determination of the relative change in energy dissipation with changing temperature. Experimental data on Young's modulus and logarithmic oscillation decrement in the interval from room temperature down to 10 K are presented for steel type 01Kh12G9N3 after several heating and cooling cycles. Figures 3.

#### Hardening of Titanium and Heat-Resistant Chrome-Nickel Alloy Threaded Fasteners by Heat-Vibration Treatment

917D0088I Kiev PROBLEMY PROCHNOSTI  
in Russian Sep 90 pp 98-103

[Article by G. V. Vasilev, A. P. Vlasov, Yu. P. Katayev; Kazan Aviation Institute imeni A. N. Tupolev, "Normal" State Production Association]

UDC 620.178.53:621.882.669.295

[Abstract] Steel and titanium threaded fasteners were hardened by heat and vibration treatment to improve creep resistance. Specimens were preloaded in extension, then vibration at various frequencies and amplitudes was added with smooth portion of the specimen bolts under creep conditions while the threaded portion was maintained under conditions of stress relaxation due to the constriction of deformation created by the presence of a harder nut. The accumulated creep deformation of the entire fastener was taken as the measure of hardening achieved. Best results were obtained under the following conditions: EI698 steel, 973 K, relative accumulated creep deformation  $P_N \times 10^4 = 25.7-28.6$ , static stress in threaded portion of bolt 520-550 MPa, mean amplitude stress in threaded portion of bolt 90-120 MPa, vibrating frequency 80-160 Hz. Best conditions for VT16 and VT3-1 titanium alloy were 623-673 K, 14.1-17.1  $P_N \times 10^4$ , 530-570 MPa, 30-40 MPa, 80-300 Hz. Figures 6; References 26; Russian.

#### Bending of Plate Coated with Diamond-Containing Layer by Vacuum Process

917D0088J Kiev PROBLEMY PROCHNOSTI  
in Russian Sep 90 pp 103-109

[Article by V. A. Podogora; Institute of Strength Problems, Ukrainian Academy of Sciences]

UDC 539.3

[Abstract] The residual thermal stresses occurring as a tool to which diamond particles have been soldered is cooled significantly influence the usage characteristics of the tool. The experimental parameter determining the residual stresses in a flexible diamond-containing tool such as a belt or disk which is easiest to measure is the bending of the tool. This requires a study of the variation in bending of the tool as a function of process parameters. Assuming the bending of a plate to be cylindrical, an elastic model is presented to explain the mechanism by which the bending arises following application of a diamond-containing layer by a vacuum process. The multilayer plate is represented as a set of plates with a fixed number of layers and known cross section, thus distinguishing the segments between grains where the two-layer plate consisting of the solder and substrate is found and areas immediately around the grains, where a three-layer diamond-solder-substrate system is present. In the model plates of these two types are connected in sequence at their ends. It is assumed that the cross sections through which they are connected are rigid in the direction perpendicular to the plane of the cross section but can deform in the longitudinal direction and can rotate at a certain angle around a point located in the diamond. Analytic expressions are derived for bending as a function of concentration and particle size of the diamond particles. The influence of the relationship of thicknesses of the layers and the mechanical properties of the plate and coating on bending are studied in the elastic statement. Numerical solution of the problem is used to study the influence of variation in mechanical properties of the solder with temperature on bending of the plate tool. The variation of bending as a function of temperature, modulus of elasticity and linear hardening modulus of the solder material is presented. Materials with different mechanical properties can be analyzed by the equations derived in this article only up to the point where cracks are formed. The formation of cracks in the solder greatly reduces the transverse bending rigidity of the structure, leading to sudden changes in bending. Figures 6; References 6; Russian.

#### Influence of Initial Structure on Hydrogen Plasticizing Effect of VT20 Titanium Alloy

917D0099A Kiev METALLOFIZIKA in Russian  
No 5, Sep-Oct 90 pp 20-25

[Article by Ye. G. Ponyatovskiy, O. N. Senkov, I. O. Bashkin; Institute of Solid-State Physics, Chernogolovka]

UDC 539.385:546.3:620.175.21

[Abstract] Previous studies have determined that the introduction of hydrogen at over 0.15% to VT20 titanium alloy greatly increases the 600-800°C ductility. This article studies the contribution of the structural factor to hydrogen plasticizing. Studies were performed

on VT20 and VT20+0.35%*H*. It is found that preliminary grinding and globularization of the grain structure significantly increase plasticity and decrease strength of the alloy, but have little influence on the alloy plus hydrogen. Under the optimal conditions for appearance of the hydrogen plasticizing effect the contribution of the structural factor is minimal. The high plasticity of the hydrogenized alloy under these conditions is caused primarily by the presence of hydrogen and its specific influence on relaxation processes, not by a reduction in grain size. Figures 3; References 9: 8 Russian, 1 Western.

**Effect of Resonant Amplification of Mirror-Reflected Wave Intensity with Asymmetrical Diffraction on Superlattice**

917D0099B Kiev METALLOFIZIKA in Russian No 5, Sep-Oct 90 pp 40-45

[Article by A. P. Ayvazyan, Yerevan State University]

UDC 548.732

[Abstract] A theoretical description is presented of the effect of resonant changes in intensity of a specular-reflected wave. A physical explanation is presented of the effect of resonant amplification of the intensity of such a wave and an expression is derived to describe the condition under which the resonant effect occurs. The resonant portion of the reflected wave appears because the diffracted wave is in turn diffracted on a set of planes, yielding a wave with the required vector. The resonant nature of the effect lies in that the satellites around two nodes lie on the Ewald sphere, possible only when the condition defined by the equation is met. Figures 5; References 16: 9 Russian, 7 Western.

**Mass Transfer in Solid Phase Upon Impact Loading of Nickel-Zirconium Pair**

917D0099C Kiev METALLOFIZIKA in Russian No 5, Sep-Oct 90 pp 94-98

[Article by S. P. Vorona, S. M. Zakharov, L. N. Larikov, V. F. Mazanko, R. L. Mezhvinskiy; Institute of Metal Physics, Kiev]

UDC 539.379.3

[Abstract] A study is presented of the mutual mass transfer in an Ni-Zr pair under mechanical impact loading in which the methods of autoradiography, Auger electron spectroscopy, optical and scanning electron microscopy, microdurametry and x-ray phase analysis were employed. The objects of the study were specimens of 99.999% pure nickel and zirconium in a well annealed state, jointly deformed by the impact of a falling weight. The impact energy was about 400 J. Loading time was  $2.4 \times 10^{-3}$  s. The mean deformation rate was  $150 \text{ s}^{-1}$ . Experiments were performed at 800°C with a thin layer of radioactive nickel about 1  $\mu\text{m}$  thick applied to the surface of the nickel specimen in contact with the

zirconium. In addition to stationary diffusion, the rate of mutual penetration of the atoms is found to differ significantly,  $M_{\text{Zr}}^{\text{Ni}} = 4 \times 10^{-2} \text{ cm}^2/\text{s}$ ,  $M_{\text{Ni}}^{\text{Zr}} = 10^{-3} \text{ cm}^2/\text{s}$  and  $M_{\text{Ni}}^{\text{Ni}} = 2.4 \times 10^{-3} \text{ cm}^2/\text{s}$ . A tetragonal phase with  $a=1 \text{ nm}$  and  $c=1.5 \text{ nm}$  is found to arise as the nickel is transferred into the zirconium. Transfer of zirconium into nickel uses a phase based on the stable compound  $\text{Ni}_3\text{Zr}$ . The depth of mutual penetration of the atoms differs by a factor of more than 3. Figures 2; References 12: 9 Russian, 3 Western.

**High-Temperature Shape Memory in Cu-Al-Mn Alloys**

917D0099D Kiev METALLOFIZIKA in Russian No 5, Sep-Oct 90 pp 104-106

[Article by I. R. Bubley, Yu. N. Koval, A. Yu. Pasko; Institute of Metal Physics, Kiev]

UDC 539.2:536.42

[Abstract] A study is made of the phenomenon of shape memory observed in the process of heating Cu-Al-Mn alloys after dynamic aging-tempering in the stressed state to determine the cause of this effect. Studies were performed on alloys in the system Cu-Al-Mn containing 11-12 mass percent Al and 2-6 mass percent Mn. The alloys were produced in an induction furnace in argon, then subject to homogenizing annealing in the area of stability of the  $\beta_1$  phase at 850°C for 20 hours. Two-stage shape memory was observed in the alloys. The first stage of shape restoration occurs by a martensite mechanism. The second, high-temperature stage is nonmartensitic. The area of appearance and extent of shape restoration in the high-temperature effect depend on the aging temperature. This stage can be related to the initial stage of eutectoid decomposition of the  $\beta_1$  phase upon aging. Figures 3; References 6: 5 Russian, 1 Western.

**Influence of Plastic Deformation on Diffusion of Impurities in Titanium and Zirconium**

917D0099E Kiev METALLOFIZIKA in Russian No 5, Sep-Oct 90 pp 107-109

[Article by A. N. Pavlychev, V. P. Zharinov; Moscow Engineering-Physics Institute, Department Number 2, Sverdlovsk]

UDC 539.219.3:548.4

[Abstract] Results are presented from an experimental study of the influence of plastic deformation on the diffusion of carbon in technical titanium and nickel in iodide zirconium. Specimens of metal rolled to a thickness of about 1.5 mm were cut on a spark cutting machine and annealed to stabilize their structure for two hours at the temperature of the upcoming experiment. After an isotope was applied to the lateral surface, the specimens were placed in a chamber where they were subjected to tension in a vacuum. A parallel specimen



was not stretched to determine the coefficient of free diffusion. At low deformation rate the diffusion factor was somewhat less than that of free diffusion in the unstressed specimen, while as deformation rate increased the diffusion factor increased rapidly. Figures 2, References 8: 6 Russian, 2 Western.

### Hydrogen in Rapidly Quenched Ti-<sup>57</sup>Fe Films

917D0099F Kiev METALLOFIZIKA in Russian No 5, Sep-Oct 90 pp 117-119

[Article by V. V. Nemoshkalenko, G. F. Kobzenko, M. M. Nishchenko, N. A. Tomashevskiy, S. S. Kharitonskiy, A. A. Shkola; Institute of Metal Physics, Kiev]

UDC 539.2

[Abstract] Results are presented from studies by Mossbauer conversion spectroscopy of the state of the near-surface layers of Ti-<sup>57</sup>Fe formed upon laser irradiation and their interaction with hydrogen upon heating. The Ti-<sup>57</sup>Fe alloy in the surface layer was produced by laser melting a film of <sup>57</sup>Fe 200 nm thick which had been applied by thermal evaporation in a vacuum of 10<sup>-6</sup> Pa to a Ti substrate 1 mm thick. The surface of the specimens was struck on the <sup>57</sup>Fe side by pulses of YAG:Nd-laser light 2.5 ms long with an energy of 0.1-0.2 J, wavelength 1.06 μm. The spectral data presented indicate that laser alloying of the titanium surface with iron formed a nonequilibrium β-solid solution of iron in titanium containing 17 at.%Fe, in which during vacuum annealing at 875 K a more equilibrium state is reached with displacement of the composition in the direction of more titanium. Annealing of the β solution in hydrogen at 775 K causes it to break down releasing α-TiFeH<sub>x</sub>, forming the TiFe phase with high sorption parameters in the surface layer. Figures 4; References 8: 2 Russian, 6 Western.

### Magnetic Moments and Magnetocrystalline Anisotropy of R- and T- Ionic Subsystems in Compounds R<sub>2</sub>(Fe, Co)<sub>14</sub>B and RFe<sub>11</sub>Ti

917D0100A Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian No 11, Nov 90 pp 53-62

[Article by N. V. Kudrevatykh, M. I. Bartashevich, V. A. Reymer, S. S. Sigayev, Ye. N. Tarasov; Ukrainian State University imeni A. M. Gorkiy]

UDC 538.22:669.25'85/86

[Abstract] Results are presented from analysis of the concentration and temperature variation of magnetization in the subsystems R and 3d ions (M<sub>r</sub>(T) and (M<sub>d</sub>(T)) and the anisotropy constants in the compounds R<sub>2</sub>Fe<sub>14</sub>B (R = Y, Nd, Sm, Gd), R<sub>2</sub>(Fe<sub>1-x</sub>Co<sub>x</sub>)<sub>14</sub>B (R = Y, Gd, x = 0-0.3) and RFe<sub>11</sub>Ti (R = Y, Dy, Ho, Er, Lu), obtained by measurements performed on single crystals. The analysis was based on the molecular field theory, previously

successfully used to interpret the magnetic properties of other intermetallic compounds of iron and cobalt. It is shown that replacement of Fe by Co in the compounds does not result in an increase in magnetization of the 3d-ion subsystem. The experimental temperature variation of this magnetization and the magnetization of the rare-earth system can be satisfactorily described by Stoner's law and anisotropic molecular theory. The magnetocrystalline anisotropy of both ionic subsystems can be interpreted by the use of a single-ion model and the crystalline field mechanism. Figures 8; References 28: 14 Russian, 14 Western.

### Structure and Magnetic Properties of Fe-Nd-B Alloys Cooled Rapidly from Liquid State

917D0100B Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian No 11, Nov 90 pp 63-66

[Article by G. P. Brekharya, Ye. A. Vasilyeva, N. N. Konev, V. V. Maslov, V. V. Nemoshkalenko, V. V. Savin; Zaporozhye State University]

UDC 669.017.911.61

[Abstract] A comparison is presented of the influence of cooling rate of structure, phase composition and magnetic properties after sintering of Fe<sub>76</sub>Nd<sub>16</sub>B<sub>8</sub> alloys, some additionally containing Tb, Dy, Ti and Mo 1 at. percent, Co 15 at. percent, obtained by rapid cooling from the liquid state on the outer surface of a spinning disk in an atmosphere of helium or gas atomization in a jet of argon. The studies showed that the structure of the strips and flakes produced by disk cooling differs significantly as a function of cooling rate. The highest cooling rates produced fully amorphous specimens, lower rates produce mixed amorphous-crystalline or fully microcrystalline specimens. The structural properties of the gas atomized specimens show smaller structural components in the smaller particles with no change in morphologic properties. The phase composition of specimens produced by both methods is virtually identical for the same cooling rates, though the structure of the phase components differs greatly. The disk-cooled specimens are more heterogeneous. The gas atomization process yields a more homogeneous structure and does not require crushing and grinding of the ingot, making this technique more effective for the manufacture of permanent magnets. Figures 4; References 9: 2 Russian, 7 Western.

### Crystalline Structure and Magnetic Characteristics of Alloy Y<sub>2</sub>(Fe<sub>0.91</sub>V<sub>0.09</sub>)<sub>17</sub>

917D0100C Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian No 11, Nov 90 pp 67-71

[Article by G. V. Ivanova, Ye. V. Shcherbakova, Ye. V. Belozerovm A. S. Yermolenko, Ye. I. Teytel; Institute of Metal Physics, Urals Division, USSR Academy of Sciences]



UDC 538.22:699.85/86

[Abstract] In a study of alloys in the ternary system Y-Fe-V, the authors detected a new phase corresponding to the composition  $Y_2(Fe_{0.91}V_{0.09})_{17}$ , but having a structure other than that of  $Y_2Fe_{17}$ . This work defines its structure and studies some of its magnetic properties. Alloys of the compositions  $Y_2(Fe_{1-x}V_x)_{17}$  with  $x = 0.06, 0.08, 0.09$  and  $0.10$  were obtained by arc or RF levitation melting. The resultant specimens were sealed in helium-filled ampules and homogenized at  $100^\circ\text{C}$  for 50 hours. The new phase is considered to be a new type of superstructure with hexagonal lattice parameters  $A = 2.43$  nm,  $C = 2.09$  nm, approximately five times greater than those of  $CaCu_5$ . The phase can be obtained by replacement of a portion of the Y atoms in the  $CaCu_5$  lattice by Fe or V atoms. The temperature variation of magnetism indicates ferromagnetic ordering of the magnetic moments. The Curie point is  $439$  K. The multiaxial anisotropy of the iron sublattice in the compound indicates that the new intermetallics cannot be considered promising materials for permanent magnets. However, the possibility of their appearance as a second phase influencing magnetic switching properties must be considered in attempts to obtain magnets based on  $R(Fe, V)_{17}$ . Figures 2; References 6: 3 Russian, 3 Western.

#### Magnetic Properties of Alloys with Competing Anisotropy Coupled with Singlet Base State of Praseodymium Ions

917D0100D Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian No 11, Nov 90 pp 81-87

[Article by A. G. Kuchin, A. S. Yermolenko; Institute of Metal Physics, Urals Division, USSR Academy of Sciences]

UDC 538.22:669.245'856/859

[Abstract] A study is made of the magnetic properties of quasibinary solid solutions of  $Pr_{1-x}Sm_xNi_5$ . These alloys have a strong competing single-ion anisotropy. It is demonstrated that the nonlinear nature of the concentration dependence of spontaneous magnetic moment and the Curie point of these alloys results from polarization of the singlet base state of the Pr ions as a result of exchange interaction with the samarium subsystem. The magnetic field factor of the exchange interaction is determined and it is shown that it can be estimated by means of the intra-sublattice magnetic field factors. It is suggested that this type of estimate is correct for any  $R_{1-x}R'_xNi_5$  with strong competing anisotropy. Figures 3; References 9: 5 Russian, 4 Western.

#### Study of Structure and Magnetic Properties of Amorphous and Crystalline Films of $Dy_{1-x}Co_x$ and Gd-Ni Alloys

917D0100E Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian No 11, Nov 90 pp 88-93

[Article by L. V. Nikitin, G. V. Smirnitckaya, O. M. Nakashidze, Ye. V. Yakhshiyeva; Moscow State University imeni M. V. Lomonosov]

UDC 539.213:538.22:669.245:669.255

[Abstract] A magneto-optical method is used to study the structural and magnetic properties of  $Dy_{1-x}Co_x$  and  $Gd_xNi_{100-x}$  films obtained by atomization in a discharge with oscillating electrons. Films were obtained by simultaneous atomization of two cathodes of rare-earth and transition metals and contained rare-earth elements over a broad concentration range from 0.2 to 90 at. percent. The magneto-optical method was found to be quite sensitive for the study of various structural states of the film condensates, allowing distinction between amorphous and fine-crystalline states, a very difficult task for x-ray phase analysis. Figures 6; References 7: 5 Russian, 2 Western.

#### Optical Properties of $\beta'$ -AgCd

917D0100F Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian No 11, Nov 90 pp 94-97

[Article by I. I. Sasovskaya, Ye. I. Shreder, Ye. Ye. Krasovskiy; Institute of Metal Physics, Urals Division, USSR Academy of Sciences; Institute of Metal Physics, Ukrainian Academy of Sciences]

UDC 541.65:669.255'73

[Abstract] This work continues a study of the influence of martensite transformations on the optical properties and electron structure of brass-type alloys on AgCd alloys. The optical properties and zone spectrum of equiatomic  $\beta'$ -AgCd are studied for the first time over a broad range of energies. Based on the calculated zone spectrum, the spectral functions  $\sigma(\omega)$ ,  $R(\omega)$ ,  $\epsilon_1(\omega)$  are computed and compared with the experimental values. Deformation of the specimen is evoked by the martensite transformation at  $293$  K and the optical properties of AgCd are studied upon martensite transformation. The plasma and relaxation frequencies of conductivity electrons are estimated from the experimental functions. The compound has very interesting optical properties in the IR band, an unusually intense absorption band not described by the zone model and probably related to a structurally unstable pretransformation state. Figures 3; References 8: 2 Russian, 6 Western.

**Electrical Properties of Sputtered Al-Cu Films**

917D0100G Sverdlovsk FIZIKA METALLOV I  
METALLOVEDENIYE in Russian No 11, Nov 90  
pp 201-202

[Article by V. F. Bashev, F. F. Dotsenko, I. S. Miroshnichenko; Dnepropetrovsk State University imeni The 300th Anniversary of Union of the Ukraine and Russia]

UDC 669.018.54

[Abstract] The purpose of this work was to determine the optimal composition and sputtering conditions for the production of thin films with precision electrical properties, and to investigate the influence of alloying elements on the lattice periods of solid solutions in such films. Ion-plasma sputtering was performed onto aluminum and copper squares. Barrier cells were used to prevent changes in the composition of the film during the course of sputtering. A sputtering time of 480 s was found to be optimal for the production of good-quality low-ohmic resistors. The  $\gamma_2$  phase has good temperature stability, heating in a vacuum to 823 K not causing a change in the crystalline lattice period. Figures 2; References 6: 5 Russian, 1 Western.

**Structure and Dynamics of Crystalline Lattice in Fe-Mn-C Alloys Studied by Slow-Neutron Scattering Methods**

917D0100H Sverdlovsk FIZIKA METALLOV I  
METALLOVEDENIYE in Russian No 11, Nov 90  
pp 112-127

[Article by V. V. Sumin, M. G. Zemlyanov, L. M. Kaputkina, P. P. Parshin, S. D. Prokoshkin, A. I. Choklo]

UDC 669.15-194.56

[Abstract] Steels of types 160G2, 110G4, 100G13, 120G16, 100G75 were studied, produced by induction-furnace melting. The Mn and C content were monitored by chemical analysis. The steels were rolled, austenitized by heating in a vacuum to 1100°C and quenching in water, then ground to remove the decarburized layer. Neutron scattering diagrams were measured on a powder diffractometer. Inelastic scattering of the neutrons was measured to determine the thermal excitation spectrum. The oscillating spectrum of the metal matrix was found to be largely independent of the concentration of Mn and C. Mechanical working was found to influence the width of the band of local oscillations of the carbon atoms. The spreading of the local band and its asymmetry are related to the cluster-formation tendency. Figures 3; References 14: 12 Russian, 2 Western.

**Mechanism of Formation of Damping Properties in  $\gamma$ -Mn-Cu Alloys with FCT Structure**

917D0100I Sverdlovsk FIZIKA METALLOV I  
METALLOVEDENIYE in Russian No 11, Nov 90  
pp 128-134

[Article by V. A. Udovenko, Ye. Z. Vintaykin, V. B. Dmitriyev, S. Yu. Makushev, N. A. Polyakova, E. Ya. Lyubimova, B. I. Shekalov; Institute of Metal Science and Metal Physics; Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin]

UDC 669.745, 35/15...

[Abstract] A study is presented of the mechanism of formation of damping properties in sound-damping structural materials in order to determine the most effective area for achievement of good damping properties in  $\gamma$ -Mn-Cu alloys. The damping properties of the alloys are found to increase greatly with separation into layers, and the best properties are those of alloys with induced FCC-FCT transition in the vicinity of the maximum of the layer-separation curve. Figures 5; References 10: 7 Russian, 3 Western.

**Influence of Hardening from Melt on Phase Transformations in Ni-Cr-Fe-Nb-Al System Alloy**

917D0100J Sverdlovsk FIZIKA METALLOV I  
METALLOVEDENIYE in Russian No 11, Nov 90  
pp 135-142

[Article by G. I. Nosova, N. A. Polyakova, V. B. Kireyev, O. V. Makushok; Institute of Metal Science and Metal Physics; Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin]

[Abstract] An electron-microscope study is presented of phase transformations in a commercial high-temperature alloy of nickel with 15 wt. percent Cr, 8 wt. percent Nb, 5.0 wt. percent Fe and 1.5 wt. percent Al, fabricated by spinning in an inert atmosphere. Results are compared with an alloy of the same composition produced by the traditional method. The results indicate that in the rapidly cooled alloy the kinetics of transformations occurring upon decomposition of the  $\gamma$ -solid solution and the morphology of the phases formed differ significantly from the characteristics in the alloy obtained by the traditional method. These differences are primarily related to the structural specifics of the rapidly cooled alloy in its initial state, determined by the high cooling rates from the melt. The thermal stresses arising upon rapid cooling from the melt stimulate processes of local plastic flow leading to significant dislocation density. A microduplex structure is formed due to significant grain-boundary migration and flow of alloying elements along the boundaries to larger  $\beta$ -phase particles. Alloys with microduplex structure have superplasticity, which should produce an interesting combination of strength and plasticity in these alloys. Figures 4; References 12: 7 Russian, 5 Western.

**Internal Stresses in Deformed Ni<sub>60</sub>Nb<sub>40</sub> Metallic Glass**

917D0100K Sverdlovsk FIZIKA METALLOV I  
METALLOVEDENIYE in Russian No 11, Nov 90  
pp 175-179

[Article by I. V. Zolotukhin, A. T. Kosilov, T. N. Ryabtseva, V. A. Khonik; Voronezh Polytechnical Institute]

UDC 539.213

[Abstract] A study of stress relaxation upon gradual load relief is used to determine the effective internal stresses arising upon extension of Ni<sub>60</sub>Nb<sub>40</sub> metallic glass. The alloy was obtained by the standard spinning method as a strip 30-35  $\mu$ m thick and 1.5 mm wide. Stress relaxation was studied after loading to about 2000 MPa and unloading to 100-300 MPa. The stress was reduced by 2-4 MPa per hour. The studies indicate that in the process of deformation, internal long-acting stress fields are formed which lead to deformation of the opposite sign and an increase in stress on the specimen as the load is released. The depth of normal relaxation is slightly greater than the increase in stresses after load relief. Stress relaxation in this material at room temperature is thus primarily inelastic. Figures 3; References 10; 7 Russian, 3 Western.

**Cyclical Low-Temperature Crack Resistance of Structural Steels and Welded Joints in Metal Structures**

917D0101A Kiev PROBLEMY PROCHNOSTI  
in Russian No 10, Oct 90 pp 8-11

[Article by V. N. Pustovoy, Odessa Naval Engineering Institute]

UDC 621.86.078.62:539.5.014

[Abstract] A study is made of the characteristics of cyclic low-temperature crack resistance of steels and welded joints of metal structures in hoisting machinery in the +20 to -70°C temperature range. Studies were performed on the structural steels primarily used in the fabrication of cranes: 09G2S, 10KhSND, St20, St-38-b2 (East Germany), VSt.3sp using compact specimens with gage length 64 mm and thickness 10 mm, loading rate 10-15 cycles per second in air. Low-temperature kinetic fatigue fracture diagrams were constructed. The fatigue threshold and intensity factor for a crack growth rate of  $10^{-7}$  m/cycle were found to be similar for all the steels tested. Figures 5; References 6; Russian.

**Fatigue Resistance of Welded Joints in High-Strength 14Kh2GMR Steel Made by Manual Arc Welding**

917D0101B Kiev PROBLEMY PROCHNOSTI  
in Russian No 10, Oct 90 pp 19-22

[Article by L. I. Mikhoduy, S. B. Kasatkin, V. D. Poznyakov, D. M. Kogut; Institute of Electric Welding imeni Ye. O. Paton, Ukrainian Academy of Sciences]

UDC 621.791.753.052:669.14.018.295:539.43

[Abstract] A study is made of the fatigue resistance of welded joints made by manual arc welding of cross-shaped specimens 80 mm wide with ribs in the most unfavorable position—transverse to the load applied to the specimens of type 14Kh2GMR steel. Three types of electrodes were used: ANP-6P, ANP-2 and UONI-13/45. The experiments showed that the use of the ANP-6P electrodes increased the fatigue resistance of the joints by a factor of 2.5-3 in comparison to the other electrodes. The chemical composition of the ANP-6P electrodes is, in mass percent: C, 0.11; Si, 0.35; Mn, 1.3; Cr, 0.34; Ni, 1.2; Mo, 0.65. The superior fatigue resistance is explained by the fact that the joints produced have a concave shape, significantly reducing stress concentration at the point of transition between the seam and the base metal. Figures 5; References 5, Russian.

**Influence of Process Factors on Metal-Glass Joint Strength**

917D0101C Kiev PROBLEMY PROCHNOSTI  
in Russian No 10, Oct 90 pp 35-37

[Article by G. I. Zhuravlev (deceased), A. A. Borisenko; Leningrad Institute of Technology imeni Lensovet]

UDC 539.4

[Abstract] A study is made of the strength of a metal-glass joint as a function of the process used to make it. An adhesiometer was developed for the study, based on determination of the shear strength of the joint. Studies were performed on phosphate glass, with some of the specimens modified by the addition of 1 mol. percent copper oxide, as well as D16 aluminum alloy, with various heat treatments and various levels of oxidation of the surface of the D16 alloy. Joints were produced in air under various temperature-time conditions. The work of adhesion, calculated from the contact wetting angle, is found to have limited correlation with the joint strength, indicating that good wetting is a necessary but insufficient condition for production of a strong joint. Joint strength increases with increasing joint formation temperature, while the time required to produce the strongest joint decreases with increasing temperature. The introduction of copper oxide to glass to be joined with D16 aluminum alloy increases the joint strength and spreads the time interval of joint formation corresponding to the maximum strength. Oxidation of the

aluminum alloy surface in oxalic acid increases joint strength, whereas electrochemical treatment in a sulfate bath is less effective. Figures 4; References 9: 8 Russian, 1 Western.

### **Mechanisms of Microplastic Deformation with Alternating Loading in the Kilohertz Frequency Band**

917D0101D Kiev PROBLEMY PROCHNOSTI  
in Russian No 10, Oct 90 pp 38-40

[Article by T. V. Golub, O. N. Kashevskaya; Institute of Metal Physics, Ukrainian Academy of Sciences]

UDC 539.43.67

[Abstract] An analysis is presented of the relationship of the amplitude-dependent portion of the oscillation decrement and Young's modulus determined by alternating loading of alloys in various structural states. Copper-based alloys with various contents of iron, aluminum and nickel were studied. The studies were intended to determine the nature of the barriers which prevent the movement of dislocations at low oscillation amplitudes. The relative change in Young's modulus with increasing resonant deformation amplitude was determined from the change in resonant frequency. In alloys containing particles of a segregated phase the strength decreased with increasing deformation amplitude. Further increases in amplitude caused an increase in strength, possibly related to multiplication of dislocations. Analysis of the relationship between the amplitude-dependent part of the oscillation decrement and the modulus of elasticity can be used to predict the behavior of materials subject to alternating loading at sonic and ultrasonic frequencies. Figures 2; References 4: 2 Russian, 2 Western.

### **Strength and Plasticity Characteristics of Metals Upon Unidirectional Deformation with Simultaneous Application of Ultrasound**

917D0101E Kiev PROBLEMY PROCHNOSTI  
in Russian No 10, Oct 90 pp 40-42

[Article by A. V. Kozlov, N. S. Mordyuk, S. I. Selitsker; Institute of Metal Physics, Ukrainian Academy of Sciences]

UDC 669.018.9:621.9.048

[Abstract] The authors previously produced an equation describing the change in strength and plasticity characteristics upon superimposition of ultrasonic oscillations on a deforming metal. This work presents and solves an additional equation describing the process of unidirectional plastic deformation of metals in an ultrasonic field, explaining the variation of stress in the specimen with time, amplitude and frequency of oscillations and the rate of unidirectional deformation. Application of ultrasonic oscillations under these conditions causes the

variable stress in the specimen to change nonharmonically over time. The alternating stresses decrease with increasing rate of unidirectional deformation. The phase shift between the alternating deformation and stress in the specimen depends on the rate of unidirectional deformation. The time interval during which plastic deformation occurs in each cycle decreases with increasing rate of unidirectional deformation and increasing amplitude of ultrasonic oscillations. The variation of mean stress with time is determined by the relationship between the amplitude and frequency of the ultrasonic deformation and the rate of unidirectional deformation. Figures 3; References 6: 1 Russian, 5 Western.

### **Influence of Loading Rate on Strength of Economical Alloy Steels at Low Temperatures**

917D0101F Kiev PROBLEMY PROCHNOSTI  
in Russian No 10, Oct 90 pp 43-46

[Article by O. Ya. Znachkovskiy, M. A. Izarov; Institute of Strength Problems, Ukrainian Academy of Sciences]

UDC 620.178.7

[Abstract] A study is made of the influence of cooling to 77 K on the crack resistance of ON9 and O7Kh13N4AG20 steels under dynamic loading and the influence of the rate of loading on the resistance of these materials to crack development. Tests were performed with three-point flexure of specimens with an initial crack on a 735 J pendulum testing machine with electronic recording equipment. Tests were performed between 298 and 77 K with specimens cooled in alcohol cooled by liquid nitrogen or directly in the liquid nitrogen. The crack resistance of the steels was found to be somewhat higher under dynamic loading than under static loading for virtually all test conditions. The impact toughness of the materials when cooled to 77 K was high, indicating that the steels are suitable for use at temperatures between room temperature and liquid nitrogen temperature. Figures 4; References 4, Russian.

### **Ambiguity of Temperature Variation in Elasticity Characteristics of Materials Using Nickel and Germanium as Examples**

917D0101G Kiev PROBLEMY PROCHNOSTI  
in Russian No 10, Oct 90 pp 54-56

[Article by V. A. Borisenko, A. I. Troyanskiy; Institute of Strength Problems, Ukrainian Academy of Sciences]

UDC 534.22

[Abstract] An experimental study was performed of the ambiguity in the elastic characteristics of technically pure materials. Experimental data are presented on the longitudinal ultrasonic wave propagation velocity in single-crystal germanium and polycrystalline high-purity



UDC 539.377

[Abstract] A study is made of the problem of determining the quasistatic thermoelastic state in a rectangular ceramic plate with plane edges freely supported around its perimeter. The quasistatic thermoelastic state in the plate is described by a system of nonlinear, heterogeneous integrodifferential equations, consisting of a nonlinear differential heat-conductivity equation considering the variation in heat-physical characteristics of the material with temperature and an integrobiharmonic equation describing the flexure of the plate as a result of thermal and force phenomena over a broad temperature range. Equations are derived for the temperature stress components produced by the nonlinear temperature field. The thermoelastic state is computed for a plate of VK 94-1 engineering ceramic. Figures 3; References 10, Russian.

#### **Stress-Strain State of Plates of Finite Size Under Acoustical Loading**

917D0101M Kiev *PROBLEMY PROCHNOSTI*  
in Russian No 10, Oct 90 pp 93-96

[Article by V. V. Karachun, Kiev Polytechnical Institute]

UDC 534.26

[Abstract] The stress-strain state is studied of a flat isotropic plate of limited dimensions, freely supported around its contour, which is equivalent to a hinge joint with conjugate structural elements in a diffuse acoustical field. Considering the bending of the plate in response to the sound wave to be small in comparison to the thickness of the plate, it is assumed that the side faces of an element in the plate are parallel to the edge faces of the plate and perpendicular to the center plane of the plate throughout all the time considered. Figures 2; References 2, Russian.

#### **Maximum Bend of Cylindrical Shell by Concentrated Force**

917D0101N Kiev *PROBLEMY PROCHNOSTI*  
in Russian No 10, Oct 90 pp 100-102

[Article by V. P. Olshanskiy, Kharkov Polytechnical Institute imeni V. I. Lenin]

UDC 539.3

[Abstract] A simple equation is derived for the bending of a shell of moderate length loaded by a radial concentrated force. The equation is obtained by summation of binary series representing the solution of the differential equations of the semimembrane theory of V. Z. Vlasov. The compact solution constructed covers the entire range of possible elongations of the shell. The results obtained agree well with known solutions of trigonometric series. The error of the equation does not exceed 1 percent, allowing its use in engineering computation of

the maximum bends of cylindrical shells in response to concentrated forces. References 10: 9 Russian, 1 Western.

#### **Geometric Sense of Coupling of Bodies and Breaking of Internal Bonds. Report 3**

917D0101O Kiev *PROBLEMY PROCHNOSTI*  
in Russian No 10, Oct 90 pp 103-109

[Article by Yu. B. Gnuchiy, V. A. Podoroga, V. V. Borisenko; Institute of Strength Problems, Ukrainian Academy of Sciences]

UDC 531+539.3+539.4

[Abstract] The displacement and deformation of simplex elements is studied, as well as matrix transformations allowing combination and separation operations to be performed on displacements and deformations. Figures 9; References 3, Russian.

#### **Installation for Determining Mechanical Characteristics of Refractory Materials**

917D0101P Kiev *PROBLEMY PROCHNOSTI*  
in Russian No 10, Oct 90 pp 110-112

[Article by V. P. Krashchenko, N. P. Rudnitskiy; Institute of Strength Problems, Ukrainian Academy of Sciences]

UDC 620.172

[Abstract] Soviet industry does not manufacture specialized machines for the study of the mechanical properties of materials in the high-temperature area. The authors of this article have modified a type FPC10/1 East German testing machine to create the M-12 high-temperature test installation which includes equipment for timely processing of the data produced in experiments. The installation includes a system for programmed heating of the specimen to reproduce the thermal conditions of use of use of structural materials. The machine can perform tests on composite materials and components, foils, strips, wires, fibers and screens. The heating element can be placed in any position in the central part of the cubic high-temperature chamber. Figures 2; References 4, Russian.

#### **Estimating Influence of Texture on Fatigue of Titanium Alloy with Aluminum and Manganese**

917D0101Q Kiev *PROBLEMY PROCHNOSTI*  
in Russian No 10, Oct 90 pp 112-115

[Article by A. F. Tarasov, A. A. Bryukhanov, T. S. Sovkova; Odessa State Pedagogic Institute imeni K. D. Ushinskiy]



UDC 669.295.5:539.43:548.735.6

[Abstract] A study is made of the influence of crystallographic texture on fatigue of specimens of OT4 titanium-based alloy containing 4.02 percent aluminum and 0.87 percent manganese. The alloy was produced by double electric-arc vacuum remelting, subjected to homogenizing annealing in a vacuum furnace, then heat treated by: 1) heating to the ( $\alpha + \beta$ ) area and 50-60 percent upsetting; 2) heating to the  $\beta$  area and 50-75 percent upsetting; 3) heating to the ( $\alpha + \beta$ ) or  $\beta$  area and rolling; 4) heating to the ( $\alpha + \beta$ ) area after treatment by methods 1)- 3). The blanks thus produced were subjected to combined heat and cold rolling with changing of the rolling direction by 45 or 90° to create various types of textures. The crystallographic factor is found to have a primary influence on the anisotropy of fatigue characteristics, though less than it has on elastic and strength characteristics. Figures 2; References 10, Russian.

#### Method of Studying Strength Properties of Reinforcing Elements in Fiber Composite Materials at High Temperatures

917D0101R Kiev PROBLEMY PROCHNOSTI  
in Russian No 10, Oct 90 pp 115-117

[Article by Yu. P. Lastovets; Institute of Strength Problems, Ukrainian Academy of Sciences]

UDC 620.172.25

[Abstract] A method and design of clamping devices are suggested for testing thin fibers and wires, allowing correct determination of the strength properties of filament materials, including brittle materials, over a broad temperature range. The essence of the method is that the specimen is indirectly heated by means of the heat-transmitting elements of the clamping devices which extend along the entire length of the specimen, and the temperature of the specimen is determined from the temperature of the heat-transmitting elements. This significantly improves the characteristics of the temperature field in the gage section of the specimen, eliminating overheating upon changes in the power of the heating system and, most importantly, allows standard primary thermoelectric transducers to be used for temperature measurement, permitting comparatively simple automation of the process of recording and regulating the temperature. Figure 1; References 6, Russian.

#### Stability of Spherical Belts

917D0101S Kiev PROBLEMY PROCHNOSTI  
in Russian No 10, Oct 90 pp 118-120

[Article by G. D. Gavrilenko; Institute of Mechanics, Ukrainian Academy of Sciences]

UDC 539.3

[Abstract] A method is suggested and tested for numerical calculation of the stability of an imperfect spherical belt (a section of a spherical shell) exposed to external pressure. It is demonstrated that the calculated and experimental critical loads can be made to agree by introducing local axisymmetrical initial imperfections to the calculation scheme. Figures 2; References 2: 1 Russian, 1 Western.

#### Reaction of Hydrogen with Ti-W-Ta Alloys

917D0102A Moscow IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA METALLY in Russian Nov-Dec 90  
pp 44-46

[Article by V. N. Verbetskiy, E. A. Movlayev; Moscow]

UDC 546.3-19,821,78,541.44,883.11

[Abstract] A study is made of the reaction of Ti-W-Ta system alloys with hydrogen. The alloys were produced by melting a charge of the initial components on a water-cooled copper hearth in an electric-arc furnace with nonconsumable tungsten electrode at 0.15 MPa argon pressure. Specimens were remelted 3-4 times to assure homogeneous composition. All the specimens studied began absorbing hydrogen at room temperature at a pressure of 20-30 atm after a certain induction period. Differential thermal analysis and x-ray phase analysis of the decomposition products were used to study the thermal decomposition of the hydride phases. The x-ray analysis indicated that the first stage of the decomposition is a complex one. Ti-W-Ta alloys containing up to 20 at.% W react actively with hydrogen forming hydride phases containing large quantities of hydrogen. Significant liberation of hydrogen begins at 470-600 K, depending on alloy composition. Active powders of these alloys may be effective hydrogen getters for a broad temperature interval. Figure 1; References 3: Russian.

#### Crystallization Rate of Hypoeutectic Alloys in Equilibrium and Quasiequilibrium Process

917D0102B Moscow IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA METALLY in Russian Nov-Dec 90  
pp 47-52

[Article by V. I. Dobatkin, A. D. Shestakov; Moscow]

UDC 669.017.3:536.421.4

[Abstract] A calculation is presented of the crystallization rate as applicable to eutectic systems with limited solubility, characteristic of most deformable alloys. The rate of crystallization is determined by the state diagram but varies depending on whether crystallization occurs under equilibrium or nonequilibrium conditions. In the equilibrium crystallization model the crystallization process is fully completed in the temperature interval

between the equilibrium liquidus and solidus, whereas in the nonequilibrium model the process extends up to the nonequilibrium solidus. The calculations of the change in the crystallization rate of an alloy in the quasiequilibrium process are based on suppression of diffusion in the solid phase and elimination of consumption of the liquid phase to increase the mean concentration of previously precipitated crystals to the equilibrium concentration of the solid phase. Figures 4; References 6; Russian.

#### Low-Carbon Chrome-Manganese Welding Steels Not Requiring Hardening in Liquids

917D0102C Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA METALLY in Russian Nov-Dec 90 pp 57-62

[Article by R. I. Entin (deceased), D. A. Litvinenko, M. N. Pankova, S. V. Uspenskaya; Moscow]

UDC 669.15'26'17-194

[Abstract] Low-temperature chrome-manganese weldable steels have been developed with favorable combination of strength, plasticity and impact toughness, simple heat treatment and the ability for significant hardening by cooling in air from the temperature of deformation or austenization, and good welding properties without preliminary heating. Eliminating hardening by quenching in liquids simplifies the production cycle, eliminates dimensional changes associated with quenching and allows final treatment of welded structures after assembly, achieving equal strength. Alloying with very small quantities of titanium and vanadium facilitates production of a smaller austenite grain, retards softening in high tempering and in some cases improves the stability of the austenite by dissolution of carbonitrides in the austenite. The steels have satisfactory welding properties without preliminary heating. Figures 4; References 9; Russian.

#### Phase and Structural Changes in Rapidly Cooled Eutectic Alloy $\text{Fe}_{63}\text{Mn}_9\text{Ti}_8\text{B}_{16}\text{C}_4$

917D0102D Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA METALLY in Russian Nov-Dec 90 pp 76-78

[Article by A. K. Shurin, E. L. Khandros; Kiev]

UDC 669-15:621,785.54

[Abstract] A study is presented of the influence of cooling rate during hardening in the range of 10 to  $10^8$  K/s on phase composition and structure of the well-known wear-resistant alloy  $\text{Fe}_{63}\text{Mn}_9\text{Ti}_8\text{B}_{16}\text{C}_4$ . This alloy has eutectic structure in the cast state. Specimens were prepared by melting in an electric arc furnace in an atmosphere of argon, cooling rates in the  $10^1$ - $10^{2.5}$  K/s range were attained by crystallizing 0.5-30 g specimens on the water-cooled furnace floor. The  $10^4$ - $10^6$  K/s range was obtained by melting a thin surface layer with a laser.

The  $10^7$ - $10^8$  K/s cooling rates were achieved by crystallization on a rapidly spinning copper disk, producing a strip 70  $\mu\text{m}$  thick and 3  $\mu\text{m}$  wide. Relatively slowly cooled specimens had the characteristic eutectic structure containing  $\text{TiB}_2$  and  $\text{TiC}$  interstitial phases plus a small quantity of  $\gamma$ -Fe. Laser treatment caused the greatest change in structure in the surface layer. All specimens retained the crystalline state of the alloy up to a cooling rate of  $10^6$  K/s. Increasing the cooling rate causes the following changes in phase composition: at  $10^3$  K/s the  $\gamma$ -Fe phase disappears, at  $10^5$  K/s the  $\text{TiB}_2$  phase disappears and at  $10^4$  K/s a  $\gamma$ -Fe and  $\text{Me}_{23}\text{O}_6$  phase appear. The latter has the  $\text{Cr}_{23}\text{C}_6$ -type crystalline lattice and is probably  $(\text{Fe}, \text{Mn})_{23}(\text{C}, \text{B})_6$ . The  $\alpha$ -Fe and  $\text{TiC}$  phases are retained up to the cooling rates of which x-ray-amorphous components appear. Figures 2; References 2; Russian.

#### Conditions and Role of Recrystallization in Transformation of Laminar Microstructure in Titanium Alloys

917D0102E Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA METALLY in Russian Nov-Dec 90 pp 83-87

[Article by M. I. Mazurskiy, G. A. Salishchev; Ofa]

UDC 669.295:548.53

[Abstract] A comparative analysis is used to determine the conditions necessary for spheroidization of the laminar microstructure in titanium alloys in order to show the significance of recrystallization in this process. It is found that recrystallization is significant primarily in that it eliminates the anisotropy of interphase energy, stabilizing the laminary form, creating the thermodynamic stimulus for spheroidization. Recrystallization, depending on how and in which phase it develops, can significantly influence the kinetics of transformation of the laminary microstructure. Figures 3; References 15; 11 Russian, 4 Western.

#### Structural Characteristics and High-Temperature Strength of Al-Si Alloys

917D0102F Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA METALLY in Russian Nov-Dec 90 pp 92-99

[Article by O. G. Pivkina, A. M. Diskin, A. Ya. Shinyayev; Moscow]

UDC 669.715'782:669.018.44

[Abstract] An estimate is presented of the high-temperature strength of Al-Si binary alloys containing 5 and 15 mass percent silicon, obtained by crystallization under pressures of 1000 and 1500 MPa, and to study the influence of structural parameters on their high-temperature strength. Studies were performed on model Al-Si alloys containing 5 and 15 mass percent silicon.

Ingots 70 mm in diameter and 1 mm high were crystallized under 1000 and 1500 MPa pressure, and specimens were cut from the central parts of the ingots. The influence of annealing on alloy structure was studied on specimens held for 10 hours at 220-500°C by microstructural analysis and quantitative metallographic analysis. The high-temperature strength depends on the number, dimension and morphology of particles segregated during decomposition of the solid solution. Short-term and long-term strength at 200-380°C are determined by the characteristics of secondary silicon particles and the structure of  $\alpha$ -dendrites of the solid solution. Addition of the pressure factor in the process of crystallization results in formation of a structure which is resistant to annealing. Crystallization at 1000-1500 MPa changes the phase equilibrium of the system in the direction of forming a silicon-supersaturated solid solution. During annealing a large quantity of dispersed silicon particles are segregated, which can serve to stop the movement of dislocations. Figures 4; References 5: Russian.

#### Metastable Phases in Ni-Nb Vacuum Condensates

917D0102G Moscow IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA METALLY in Russian Nov-Dec 90  
pp 138-144

[Article by L. A. Zhukova, S. V. Tretyakov, A. A. Zhukov, Yu. M. Shcherbakov; Sverdlovsk]

UDC 669.018.95:539.213

[Abstract] A study is made of Ni-Nb alloys obtained by various methods of sputtering in the form of films of various compositions and thicknesses, as well as metastable phases formed in the Ni-Nb system upon cooling from the liquid state. Studies are performed by electronography of specimens about 20 and about 80 nm thick cooled on colloidal substrates at  $10^{-5}$  mmHg. It is found that the formation of the BCC phase is facilitated in thin condensates in comparison with thicker continuous films. The FCC-BCC conversion in them occurs practically completely over time. A high content of niobium was obtained in the condensates only by simultaneous precipitation of the vapors of the components with elevated evaporation rate of Nb. At 36 and 42 mol.% Nb the amorphous state was achieved in the films. Figures 3; References 9: 7 Russian, 2 Western.

#### Phase Diagrams of Systems Sc-Ta-Si and Sc-Ta-Ge at 1070 K

917D0102H Moscow IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA METALLY in Russian Nov-Dec 90  
pp 200-202

[Article by B. Ya. Kotur, O. I. Bodak; Lvov]

UDC 669.793'294'772+669.793'294'783

[Abstract] A study is made of the reaction of the components in the systems Sc-Ta-Si and Sc-Ta-Ge at 1070 K over the full concentration interval for the first time. Specimens were prepared by electron-arc melting in an atmosphere of purified argon using charges of the specimens of at least 0.999 mass parts purity. The results of the phase analysis are presented in triangular phase diagrams. The systems are similar in the reactions of the components to the system Sc-Nb-Si (Ge) and the system Sc-W-Si (Ge). Figure 1; References 9: 7 Russian, 2 Western.

#### Phase Equilibria in W-Fe-Co-Ni Alloys Containing 10% (Fe+Co+Ni) at 800

917D0102I Moscow IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA METALLY in Russian Nov-Dec 90  
pp 203-207

[Article by A. M. Zakharov, A. V. Nikolskiy, V. G. Parshikov, L. S. Vodopyanova; Moscow]

UDC 669.017.14

[Abstract] The phase composition of alloys of tungsten with 10% (Fe+Co+Ni) is studied at 800 and 575°C considering the latest experimental data on the state diagrams of W-Fe and W-Ni, which discovered new stable intermediate FeW, NiW and NiW<sub>2</sub> phases. In the system W-Fe the FeW phase at about 1215 and 1190°C participates in peritectoid  $\alpha+\mu$ -FeW and eutectoid  $\mu-(\alpha, \delta)+\text{FeW}$  equilibria, where  $(\alpha, \delta)$ -solid solution is based on  $\alpha$  (or  $\delta$ )-Fe, and in the W-Ni system the phases NiW and NiW<sub>2</sub> at 1093-1048 and 1040-1010°C participate in the corresponding peritectoid equilibria  $\alpha+\gamma$ -NiW and  $\alpha+\text{NiW}-\text{NiW}_2$ , where the  $\gamma$ -solid solution is based on nickel. Figures 2; References 9: 6 Russian, 3 Western.

### Structural-Mechanical Model of Amorphous-Crystalline Polymers

917D0033A Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian Jul-Aug 90 pp 585-593

[Article by V. V. Kostitskiy, Institute of Machine Science imeni A. A. Blagonravov, USSR Academy of Sciences, Moscow]

UDC 620.18:678.01:539.32

[Abstract] The mechanical properties of amorphous-crystalline polymers cannot be described within the framework of a single model. The major idea of this article, the basis of creation of a structural model for amorphous-crystalline polymers, is fixation of the basic levels of the supermolecular structure formed in all stages of production and processing of a polymer, assuming that the initial parameters of each subsequent model structure are the output parameters of the previous structure and the parameters of the corresponding technological operation leading to the change in the previous structure. The basic ideas of this method are discussed on the example of construction of a model for the supermolecular structure of a spherulite-structure polymer formed by crystallization of amorphous-crystalline polymers. The structural-mechanical model consists of three interconnected structural models recording the three basic stages of formation of the supermolecular structure: a model of the disoriented state of the spherulite structure, a model of uni- and biaxially oriented spherulite structure and a model of the fibrillar superoriented structure of the amorphous-crystalline polymers. The model satisfactorily reflects the spherulite structure of the amorphous-crystalline polymers even in the approximation of homogeneous interaction. The elastic constants obtained by construction of the model are used as the initial data for construction of the model of the supermolecular structure formed in the process of orientation drawing of amorphous-crystalline polymers with spherulite structure. Figures 3; References 28: 18 Russian, 10 Western.

### Warping of Printed-Circuit Boards Due to Glass-Reinforced Textolite Structure Defects

917D0033B Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian Jul-Aug 90 pp 605-609

[Article by V. V. Bulatov, A. A. Gusev, A. P. Rodkin, V. I. Zaytsev, E. F. Oleynik, Institute of Chemical Physics, USSR Academy of Sciences, Moscow; All-Union Scientific Research Institute of Electrically Insulating Materials, Moscow]

UDC 624.074.001:678.067

[Abstract] A study is made of the warping of a layered board due to heterogeneity of the thermomechanical parameters of the layers. A thin plate is considered, the local thermoelastic properties of which depend only on

the coordinates of a point relative to the mean plane and are homogeneous in the plane of the plate. The study is limited to the case when the plate is symmetrical relative to the center plane and is orthotropic by layers. Disruption of orthotropic symmetry of the layers and shear warping of glass-reinforced textolites are considered. Analysis of the experimental data indicates that the model of warping of PC boards produced is adequate. The disorientation of prepreg layers and skewing of reinforcing filaments may cause warping of PC board materials. The concepts developed in the article can be used to create multilayer composites with high shape stability. Figures 3; References 9: 3 Russian, 6 Western.

### Semisolid Model of Deformation of Twisted Multilayer Composite Rods

917D0033C Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian Jul-Aug 90 pp 610-614

[Article by T. D. Karimbayev, Central Institute of Aviation Motor Building imeni P. I. Baranov, Moscow]

UDC 539.4:621.2

[Abstract] One version is presented of a theory of deformation of multilayer rods in which the specifics of the structure of physical relationships for composite materials and the influence of the multilayer nature of the structure on the kinematic and rigidity characteristics of the rods are considered. The approaches developed allow determination of effects inherent in twisted composite rods, such as the variation of stresses and strains with type of individual layers and nature of placement of reinforcing elements, their asymmetry in the sections and the specifics of their interactions. The twisted rods are studied in both nonmoving and local systems of coordinates. The calculation results are compared with experimental data based on results published in the literature. It is concluded that the stress-strain state of naturally twisted rods made of composite materials can be computed by the analytic approach developed in this article, based on a number of assumptions concerning the kinematic relationships and equilibrium conditions. An algorithm is developed for computer calculation of the stress and strain parameters in each layer. The results of calculation agree satisfactorily with the experimental data over a broad range of longitudinal load. Figures 5; References 5: 4 Russian, 1 Western.

### Basic Problems of Mechanics of Spirally Anisotropic Media

917D0033D Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian Jul-Aug 90 pp 615-620

[Article by G. Ye. Freger, N. A. Karvasarskaya, I. Yu. Kireyev; Voroshilovgrad Machine-Building Institute]



UDC 539.319.678.027.94

[Abstract] An analysis is presented of problems related to the mechanics of spirally anisotropic media, a review is presented of the basic results and the possibility of their application to improve the technology of manufacturing spirally anisotropic composites, and basic trends in prospective studies are noted. The results presented allow estimation of the strength of spirally anisotropic media from the standpoint of the limiting state theory, according to which the failure of a medium occurs under conditions such that at some point the combination of stress and strain tensor components reaches a critical value. The limited nature of this approach for composites is known. The introduction of spirally anisotropic layers should influence the kinetics of accumulation of damage within the structural elements as well as the developments and propagation of microcracks. Experimental study of these processes must serve as the foundation for simulation of the failure process in such media on computer models. Figures 5; References 15; Russian.

#### Heat Conductivity of Reinforced Plastic Foam

917D0033E Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian Jul-Aug 90 pp 621-623

[Article by M. P. Gaylite, A. M. Tolks, A. Zh. Lagzdin, A. E. Terauds; Institute of Polymer Mechanics, Latvian Academy of Sciences, Riga]

UDC 536.21:678.664

[Abstract] Two versions of construction of structural heat conductivity equations are considered. A transversely isotropic computation element is isolated in a chaotically reinforced plastic foam element as a circular cylinder consisting of the reinforcing element on the axis of the cylinder and a cylindrical layer of the polymer matrix and gas. It is assumed that these computation elements are oriented uniformly in all directions. An equation is derived for the resultant heat conductivity of the reinforced plastic foam and the calculation results are compared with experimental data. The results agree satisfactorily, considering that the initial gas content of the foam bubbles is freon, which later diffuses out and is replaced by air. Figures 2; References 8; 7 Russian, 1 Western.

#### Multicycle Fatigue Resistance of Brittle Polymers

917D0033F Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian Jul-Aug 90 pp 633-638

[Article by S. B. Ratner, L. B. Potapova; Scientific Research Institute of Plastics, Moscow; Khabarovsk Polytechnical Institute]

UDC 539.4:678.067

[Abstract] The durability of brittle polymers is predicted based on an integral equation reflecting the damage accumulated in the polymer as a result of repeated loading. A model of the development of a fatigue crack is considered in which the enlargement of a macroscopic defect is accompanied by concentration of stresses at the tip, with the stress field in the transition zone defined by a single parameter, the stress intensity factor. The constant nature of dimensionless parameters in a cascade of defects leads to the hypothesis of self-similarity. Caprolon and its composite with 2-6% dispersed graphite and cover oxide particles is studied. The cyclical durability is found to be 5-6 times less than that calculated by the equation previously used. A new model of multicycle fatigue of polymers is suggested, based on the hypothesis of self-similarity. Under low-temperature conditions, the basic factor causing fatigue fracture is a crack. A new equation for cyclical durability is obtained, consisting of a modified criterion of the total time, written for the stress state at the point of failure near the tip of a fatigue crack. It is shown that in the case of brittle failure with multicycle fatigue the fracture criterion is the maximum primary stress arising at the point of failure, which is an order of magnitude less than the length of the fatigue crack. Figures 4; References 19; 18 Russian, 1 Western.

#### Optimization of Structure of Reflecting Cylindrical Multilayer Coating Interacting with Plane Acoustical Wave

917D0033H Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian Jul-Aug 90 pp 639-645

[Article by K. S. Adamova, M. A. Kanibolotskiy; Institute of Physical-Technical Problems of the North, Yakutsk Scientific Center, Siberian Division, USSR Academy of Sciences, Yakutsk]

UDC 543.833

[Abstract] This article analyzes the problem of optimal design of a cylindrical multilayer sound-reflecting shield. The process of propagation of elastic waves is two dimensional, depending on the radial and angular coordinates. The problem is formulated as a problem of optimal control. A numerical algorithm is developed for construction of a minimizing control sequence based on an equation for functional increments. Two examples of computation are presented. The structure of the multilayer cylinder is optimized to minimize the total oscillating energy of the acoustical medium within the cylinder. Figure 1; References 7; Russian.



### Standardizing the Methodology for Determining Classification Categories for Atmospheric Corrosivity

917D0086A Moscow ZASHCHITA METALLOV  
in Russian No 6, 1990 pp 883-896

[Article by P. V. Strekalov, Yu. M. Panchenko, Z. G. Yegutidze; USSR Academy of Sciences Institute of Physical Chemistry]

UDC 620.193.2

[Abstract] In order to validate the methodology described in ISO DIS draft standards, the State Scientific Research Institute for Materials Protection carried out a four-year program in which metal specimens were subjected to atmospheric corrosion. Two groups of specimens were tested at corrosion stations in Murmansk, Batumi, Vladivostok, and Oymyakon. One group consisted of flat specimens 150 by 100 mm made from St3 carbon steel, TsO zinc, AO aluminum, and M1 copper. The other group consisted of spiral specimens 25 mm in diameter and 90 mm in height and made from the same type of steel and copper and from Ts1 zinc and A5 aluminum. The spiral specimens were made by winding a piece of wire 1000 mm long and 3 mm in diameter about a polyamide rod 25 mm in diameter. The flat specimens were slanted at a 45° angle to the south. The spiral specimens were tested vertically. A total of 210 specimens was tested at each station. Air temperature and humidity were constantly monitored; SO<sub>2</sub> and Cl ions in the air were monitored daily, weekly, monthly, or bimonthly depending on the location. The specimens were exposed for periods ranging from three months to four years. The results showed that measurements of atmospheric corrosivity determined from two different methodologies, one employing corrosion test data and the other atmospheric data, yield a coincidence rate of 83% for zinc, 72% for steel, 39% for aluminum, and 33% for copper. Figures 4, tables 4; references 6; 2 Russian, 4 Western.

### Protective System for an Industrial Power Station

917D0086B Moscow ZASHCHITA METALLOV  
in Russian No 6, 1990 pp 1029-1032

[Article by G. P. Tishchenko, B. I. Melnikov, I. G. Tishchenko, V. V. Orlenko, S. I. Tereshchenko, V. I. Shakalov, V. Ye. Nikonorov; Dnepropetrovsk Chemical Technology Institute, Dnepropetrovsk Equipment Engineering Department, All-Union Order of the Red Banner of Labor Scientific Research Institute for Chemical Reagents and Especially Pure Chemical Substances, Dnepropetrovsk Industrial Power Station]

UDC 663.4:620.197

[Abstract] Two methods of chemical cleaning were developed and adopted in order to improve the performance characteristics of DKVR-20/13 boilers. One

method involves operational maintenance cleaning to remove sediments of complex composition; the other method involves removing the sediments while the boiler is in use. The operational cleaning is done in two stages. First the system is flushed for six to eight hours with a 1 to 2%-solution of hydrochloric acid containing 1 g/l each of 1-oxyethylidinediphosphonic acid and Kantax [kantaks] with inorganic phosphate dispersant, a new corrosion-inhibiting mixture. Solution temperature is held at 60-80°. A 2%-solution containing 5-6 g/l of oxyethylidinediphosphonic or nitrilotrimethylphosphonic acid is then circulated for three days at 130-170°. This method removes 80% of the boiler sediments. With the "in use" method, a solution of zinc complexonate is continuously added to the feed water by an automatic metering device. This method inhibits the precipitation of barely soluble compounds, helps to gradually remove sediments during boiler operation, and reduces sludge-induced corrosion by keeping the internal heating surfaces clean. These methods are used in conjunction with a feed and process water circulatory system to protect the components of the power plant. Other elements of the protective (corrosion-inhibiting) system are described. The adoption of this system increased average boiler efficiency from 90 to 92% while reducing the corrosion rate 30-50%. Constant use of the "in use" method over a two-year period resulted in sediment-free operation of all DKVR-20/13 boilers. Figures 1; references 4; Russian.

### Accelerated Testing of Threshold Stresses

917D0086C Moscow ZASHCHITA METALLOV  
in Russian No 6, 1990 pp 1032-1034

[Article by V. M. Kushnarenko, A. P. Fot, N. G. Goncharov, V. S. Ikhanov, S. I. Pavlov; Orenburg Polytechnic Institute]

UDC 620.171:620.194.85

[Abstract] An accelerated method of testing threshold corrosion-cracking stress was developed. The method involves subjecting four types of steel and four types of electrode metal to a constant tensile load and to a constant rate of elongation while exposed to NACE medium or air. For each material, at least three groups of five cylindrical specimens were tested according to standard methodology. This data was used in conjunction with a simple mathematical model of corrosion behavior and its effect on the strength and plasticity of the test materials to develop an equation that would measure threshold stress. When used together with the Mann-Whitney test, this equation can be applied to the accelerated testing of threshold corrosion-cracking stress with satisfactory results. Tables 3; references 5; 3 Russian, 2 Western.

### Microalloying of Steel 10Kh18N9BL With Nitrogen

917D0075A Moscow LITEYNOYE PROIZVODSTVO  
in Russian No 9, Sep 90 pp 8-9

[Article by L. A. Shaporenko, V. I. Reshetneva, E. S. Yakimenko, N. A. Keselev]

UDC 621.74:669.18.046.516.2:669.786

[Abstract] Microalloying of steel 10Kh18N9BL with nitrogen is examined. Steel was made in an IST-0.16 induction furnace with basic lining. FKHN600A ferrochrome with 7.5% Ni and 66% Cr was used for adding nitrogen to steel. The design amount of alloying nitrogen addition was 0.05, 0.1, and 0.15%. The total nitrogen content in the ready metal was determined by the vacuum melting method. The results of the study show that microalloying of steel 10Kh18N9BL with 0.05-0.1% nitrogen makes it possible to obtain an austenite structure while maintaining high ductile and impact characteristics. It is expected that this steel will be tested further in making thin-walled castings. It is emphasized that in making thick-walled castings from steel with an elevated nitrogen concentration, thin aluminum nitride inclusions precipitate along the primary austenite grain boundaries, resulting in embrittlement. It is suggested that in order to avoid the formation of aluminum nitrides, stronger deoxidizers (i.e., Ti and Zr) be used in order to bind nitrogen and prevent the AlN formation. Tables 1.

### Effect of High Manganese Steel Inoculation on Wear Resistance of Parts

917D0075B Moscow LITEYNOYE PROIZVODSTVO  
in Russian No 9, Sep 90 pp 13-14

[Article by V. N. Sazhnev, L. B. Cherepinskiy, V. M. Shamin, V. S. Solodovnikov, Yu. V. Kononov; Zaporozhye Mechanical Engineering Institute]

UDC 621.74.011.19

[Abstract] The effect of Ti and V on the wear resistance of steels 110G13L, 110G10L, and 110G8L in the course of abrasive, impact abrasive, and impact abrasive-corrosive wear of smeltings was examined in an IST-0.16 induction furnace with basic lining by sampling batches of metals so as to rule out the effect of extraneous factors. Tests were conducted in a pilot 680x700 mm ball mill at a 34 min<sup>-1</sup> rotational speed for 100 h for each type of wear using 9x9x20 mm samples (3-5 for each wear type). Steel 110G13L was used as a standard. Wear resistance was calculated as a ratio of the standard mass loss to the sample mass loss. Nepheline ore with a 20-45 mm fraction was used to determine wear resistance. It is established that comprehensive inoculation of high manganese steels with Al, Ti, and V is optimal for castings operating under the conditions of abrasive and impact wear; for operation under the conditions of impact abrasive-corrosive wear, additional vanadium

inoculation is inefficient. It is demonstrated that despite certain advantages of the wear resistance of steels 110G10L and 110G8L over steel 11G13L, their impact viscosity and ductility do not always ensure reliable equipment operation. Figures 1; tables 1.

### Method of Selecting Engineering Steels for Low-Temperature Applications

917D0095A Moscow METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV  
in Russian No 11, Nov 90 pp 38-41

[Article by A. V. Vikulin, Yu. P. Solntsev; Leningrad Technical Institute of the Refrigeration Industry]

UDC 620.178.3:669.14.018.298

[Abstract] A methodology and criteria for selecting engineering steels for low temperature applications was developed. In addition to service temperature, this method also takes into account product size and shape, the presence of cracks, the nature of the load, and the stress levels. Low- and medium-strength mechanically worked and cast steels and 15Kh2NMFA steel were used in the study. The method consists of the following steps. First, Type 11 specimens (deeply notched) are used to perform standard impact toughness tests on a candidate steel, and its critical temperature is determined. Then a graph showing a strength vs temperature function is used to determine whether the steel is suitable according to a cold-resistance criterion that is mathematically expressed by an inequality describing the ductile fracture transition condition. If this criterion is met, then another criterion for cracking resistance is applied. This criterion is also expressed as an inequality, the left side of which describes the critical length of a crack in an endless stressed plate, and the right side describes the critical length of a crack in a product manufactured from a candidate steel. An example of how this method could be applied to selecting a specific steel for a specific application was provided. Figures 2, tables 1; references 6: Russian.

### Effect of Cold Working and Heat Treatment on the Structure and Mechanical Properties of Titanium- and Cerium-Alloyed Br013 Bronze

917D0095B Moscow METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV  
in Russian No 11, Nov 90 pp 53-56

[Article by V. F. Shamray, Yu. V. Yefimov, V. A. Lykhin, V. V. Nesgovorov, M. I. Timofeyev, T. M. Frolova; Institute of Metallurgy imeni A. A. Baykov, Gorizont Special Design Bureau]

UDC 669.35:621.77+621.78

[Abstract] The purpose of this study was to investigate the structure and mechanical properties of Br013-type bronze alloys alloyed with titanium (0.5-1%) and up to

0.1% cerium and subjected to cold working, with subsequent heat treatment. The test alloy (Cu, 13% Sn, 0.7% Ti, 0.16% [sic] Ce) and a master alloy (Cu, 13% Sn) were made from pure raw materials by triple melting in graphite crucibles in a high-frequency induction furnace with an Ar atmosphere. The metals were teemed into one-piece metal molds 120 X 35 X 15 mm. The castings were formed into bars from which specimens were cut, cold-rolled between smooth or grooved rolls to reduce their cross-section by 5-80%, and heat-treated in a 0.001-Pa vacuum at 200-750°C for 1 to 24 hours. The specimens were then subjected to microscopic, x-ray, chemical, and activation analyses, and their microhardness, strength, and plasticity measured. The data showed that

the Ti- and Ce-alloyed bronzes are more sensitive to oxygen and carbon contamination than the master alloy. Although the recrystallization point is virtually unaffected by these elements, they slow the pace of full recrystallization throughout the entire metal mass, which occurs at 450-500°C for the master alloy and at 500-600°C for the test alloy after a one hour soaking period, as well as grain growth when the temperature and annealing period are increased. To obtain the desired structure and mechanical properties, the alloy should be cold rolled to effect a 40-60% reduction, then annealed at 600-750°C for 1-24 hours. Figures 4; references 7: 1 Russian, 6 Western.

**Optimal Conditions of Electric Extraction of Cobalt From Sulfate and Chloride Solutions**

917D0089A Moscow TSVETNYYE METALLY  
in Russian No 11, Nov 90 pp 45-48

[Article by V. L. Kubasov, G. A. Vorobyev, T. V. Galantseva, L. A. Tertichnaya, E. S. Litvinenko; State Scientific Research Institute of Nonferrous Metals and NGMK]

UDC 541.135.52

[Abstract] Electrolytic methods of cobalt production are examined from the viewpoint of optimizing the process in order to obtain metal of a given quality with the highest current efficiency. A special anode with an active mass consisting of cobalt oxides was made for sulfate solution electrolysis and an anode with a ruthenium and titanium oxide active mass was made for the electrolysis of chloride solutions. The use of these anodes eliminated the contamination of cathode precipitates with decomposition products of other types of insoluble anodes. Solutions were prepared from high-purity salts. The cathodes were made from the VT1-0 titanium. The current efficiency was calculated by a given current and electrolysis duration. The processing of experimental data produced regression equations; their analysis reveals that response surfaces do not have extrema; the resulting relationships for the current efficiency and cathode precipitate quality are consistent with data in published sources. It is shown that optimal chloride electrolysis conditions lie in the range of higher current density and cobalt concentration values than those of the sulfates. Thus, it is possible to attain a higher current density in the case of chloride solutions for producing high-quality metal; this is consistent with cobalt exchange currents in chloride and sulfate solutions. References 15: 13 Russian; 2 Western; tables 2.

**Studies of Hydrogen Reduction Kinetics During Electrolytic Precipitation of Copper From Zinc Sulfate Solutions**

917D0089B Moscow TSVETNYYE METALLY  
in Russian No 11, Nov 90 pp 48-52

[Article by V. Ye. Benyash, N. P. Pestunova; All-Union Scientific Research Institute of Nonferrous Metals]

UDC 669.536.23

[Abstract] Kinematics of hydrogen reduction as well as the behavior of precipitates during the refining are examined for the purpose of optimizing the electrolytic precipitation refining of zinc electrolyte. Studies were carried out in a unit consisting of a temperature-controlled sealed vessel with a control thermometer, pH-meter electrodes, and a gas discharge tube. Chemically pure zinc and copper sulfate salts were used to prepare solutions. The quality of blue powder was monitored and zinc was regarded as suitable if no

hydrogen was released from it. Research data show that it is expedient to conduct electrolytic precipitation of copper beforehand in order to lower electrolytic precipitation losses while the countercurrent flow feed of blue powder is inefficient since the time of powder contact with the electrolytic precipitate increases; this leads not only to additional zinc losses due to the hydrogen formation but also to a blue powder deactivation by tribasic zinc sulfate. References 13: 11 Russian; 2 Western; figures 4; tables 2.

**New Flocculants in Hydrometallurgy of Zinc**

917D0089C Moscow TSVETNYYE METALLY  
in Russian No 11, Nov 90 pp 52-53

[Article by G. N. Vanyushkina, All-Union Scientific Research Institute of Nonferrous Metals]

UDC 669.536.221

[Abstract] Ten samples of high-molecular polyacrylamide compounds used as flocculants were tested in order to improve technological indicators of the thickening of pulp at the Leninogorsk Zinc Works. All commercial flocculant powder samples had a 98% content of the main substance and represented water-soluble polymers with a high molecular mass; the latter fact has a significant effect on their flocculation activity. Test results make it possible to identify the three most effective flocculants (Nos. 1, 4, and 9) for the thickening of pulp in hydrometallurgical refining and suggest them for implementation. It is shown that the use of the flocculants makes it possible to improve the performance of the zinc-making pulp thickening process: reduce the flocculant rate by more than threefold and decrease the concentration of solids in the thickener overflow from 8.0 to 3.0 g/l or less. References 5.

**Development of Electrode Graphite Material for Plasma Arc Remelting Furnace**

917D0089D Moscow TSVETNYYE METALLY  
in Russian No 11, Nov 90 pp 66-68

[Article by N. V. Shatilova, B. I. Davydovich, N. D. Afanasyev, O. S. Muradyan; State Scientific Research Institute of Economics and Planning and Izhtal Works]

UDC 661.666.2:621.365

[Abstract] The erosion rates of tungsten and graphite electrodes in an oxygen-containing gaseous medium are compared; these materials are virtually equivalent to each other. An experimental batch of graphitized electrodes was made for the U-600 plasma arc refining furnace plasma generator. The material for the electrodes was made from icicular coke. Graphitized electrodes were tested during the remelting of a commercial batch of steel 20KhN3A ingots. A mixture of argon and nitrogen and argon were used as the plasma-forming gas. As a result of the studies, it is recommended that 2-3% of



lanthanum oxide be added to the graphitized material. The use of plasma generators with graphite electrodes made it possible to produce ingots without tungsten inclusions thus increasing the chemical homogeneity and mastering production of new brands of steel for critical purposes: EP-303, R2M5, VNS-53, etc. Commercial production tests of the new pilot graphitized electrodes revealed that they have a low wear. References 3; tables 2.

### Investigation of Ultrasound Damping in Molded Carbon Blanks

917D0089E Moscow TSVETNYYE METALLY  
in Russian No 11, Nov 90 pp 68-70

[Article by G. M. Mikhaylyuk, N. V. Negutorov; State Scientific Research Institute of Economics and Planning]

UDC 620.179.16

[Abstract] Data of experimental measurements of the damping factor of longitudinal ultrasonic oscillations at a 0.6-5.0 MHz frequency in molded electrode blanks with a 130, 230, and 375 mm diameter are presented. For comparison, molded fine-grain blanks with a 140 mm diameter produced by cold extrusion into a mold were also examined. The damping factor was measured by the variable length method whereby the amplitudes of ultrasonic signals with different path lengths in the material under study are compared. It is shown that the size of the filler coke grain and blank material porosity are the main factors affecting the ultrasonic oscillation amplitude attenuation in molded carbon blanks; fine-grain hot molded blanks with a mean filler grain dimension of <0.6 mm have the least ultrasonic damping, so the echo-method at ultrasonic vibration frequencies of 0.6-2.5 MHz can be used for nondestructive testing. It is expedient to use the low-frequency direct shadow method with a working frequency band of 0.6 MHz or less for testing coarse-grain and porous blanks characterized by a high ultrasonic damping. References 5; figures 1; tables 1.

### Molybdenum Sorption From Nitrate Solutions by Phosphorus-Containing Ampholytes

917D0089F Moscow TSVETNYYE METALLY  
in Russian No 11, Nov 90 pp 70-75

[Article by S. G. Voldman, V. K. Romyantsev, V. V. Kulakova; All-Union Scientific Research and Design Institute of Refractory Metals and Hard Alloys]

UDC 669.28

[Abstract] The sorption of molybdenum by certain nitrogen- and phosphorus-containing ion exchangers is examined. The ANKF-1 vinylpyridine bifunctional ampholyte gel and AFI-21 and AFI-22 macroporous polystyrene ampholyte were used; for comparison, the VP-1p vinylpyridine macroporous anion exchange resin

and KF-7 phosphoric cationic exchanger were also used. Ion exchangers were conditioned beforehand using a standard technique and charged to a nitric form. It is shown that the patterns of molybdenum sorption from neutral and weakly acidic solutions by the AFI-21, AFI-22, and VP-1p ion exchangers are the same, thus attesting to the anion exchange mechanism of the process. The results demonstrate that nitrogen- and phosphorus-containing ampholytes and phosphoric cation exchangers are a promising class of sorbents for extracting molybdenum from acidic solutions, especially those with a low metal concentration. References 9; figures 9; tables 2.

### Strontium Dioxide Granulation Process in Rotary Kilns

917D0089G Moscow TSVETNYYE METALLY  
in Russian No 11, Nov 90 pp 79-81

[Article by V. L. Garber, M. A. Fishteyn, A. Katayev, A. M. Kazban; Sredaztsvetmetenergo and Isfarin Hydro-metallurgical Works]

UDC 66.099.2:669.892

[Abstract] Granulation of strontium dioxide in rotary kilns is examined in order to ascertain the particles' conformity with GOST requirements. The studies show that the fracturing of large strontium dioxide granules is accompanied by the formation and accumulation of a large amount of fractions with a size <0.1 mm in the ready product, prompting the development of methods which ensure that the granulometric composition is close to commercial specifications (0.8-0.1 mm). A comparison of the results of a mesh analysis of material samples from rotary kilns and the results of thermal measurements made it possible to establish characteristic features of the granulation process which show that strontium dioxide granules are formed after the removal of moisture from the material. It is recommended that granulation of strontium dioxide be combined with the drying process in the same rotary kiln with individual heating while the granule caking be conducted in another rotary or tunnel kiln. Implementation of these measures made it possible to develop commercial production of granulated strontium dioxide in the USSR whose indicators are at least as good as those of similar U.S. and Japanese products. References 3; figures 3.

### Optical Properties of Oxygen-Doped Zinc Selenide

917D0090A Moscow IZVESTIYA AKADEMII NAUK  
SSSR: SERIYA NEORGANICHESKIYE MATERIALY  
in Russian Vol 26 No 11, Nov 90 pp 2280-2284

[Article by M. P. Kulakov, V. D. Negriy; Solid State Physics Institute at the USSR Academy of Sciences]

UDC 621.315.592

[Abstract] Optical properties of zinc selenide crystals grown from a melt under an argon pressure are investigated. Nominally nondoped crystals contained  $1 \times 10^{19}$  cm<sup>-3</sup> oxygen while its maximum content reached  $9 \times 10^{20}$  cm<sup>-3</sup>. Photoluminescence of 5x5x2 mm samples placed in a cryostat with a 4-77K controlled temperature was measured by a DFS-12 spectrometer with a 0.4 nm/mm dispersion and a 0.1-0.3 mm slot width. Absorption in the mid-infrared spectrum was examined by a Specord 75-IR spectrometer with an 8 cm<sup>-1</sup>/mm dispersion at 300 and 80K. The ZnSe<sub>1-x</sub>O<sub>x</sub> crystals under study turned out to be unusual: oxygen doping leads to a heavy donor doping due to the noncentered binding of the less electronegative (relative to oxygen) basic lattice component by the isovalent impurity. In crystals grown from a melt in graphite crucibles, the presence of oxygen was not detected by optical methods. References 18: 9 Russian; 9 Western; figures 4.

#### Photoelectric Properties of Thin TiInSe<sub>2</sub> Films

917D0090B Moscow IZVESTIYA AKADEMII NAUK SSSR SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 11, Nov 90 pp 2288-2290

[Article by S. N. Mustafayeva, M. M. Asadov, D. I. Ismailov]

UDC 621.315.592

[Abstract] The results of an examination of photoelectric properties of thin single crystal TiInSe<sub>2</sub> films with super-constants are cited. Samples of 0.5 μm thick films under study were grown on a NaCl substrate with a 2 mm spacing between contacts. The electric field was applied to the samples along TiInSe<sub>2</sub> films with a vertical light incidence upon them. The studies show that the films' forbidden band is 1.8 eV wide. Photo current relaxation in these films is due to the trapping of charge carriers by low-lying states. The films' photostimulated polarization is substantially more effective than their dark polarization. Measurements show that the greatest charge released during the photostimulated depolarization reached  $4 \times 10^{-7}$  coulomb. References 1; figures 5.

#### Hydration of Titanium-Tungsten Alloys

917D0090C Moscow IZVESTIYA AKADEMII NAUK SSSR SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 11, Nov 90 pp 2305-2308

[Article by V. N. Verbetskiy, E. A. Movlayev; Moscow State University imeni M. V. Lomonosov]

UDC 541.44.546.3-19.821.78

[Abstract] Interaction between alloys of titanium with tungsten and hydrogen is described for the first time. Samples were prepared by fusing a charge of initial materials - titanium iodide and tungsten powder tablets

- on a water-cooled copper hearth of an electric arc furnace with a nonconsumable tungsten electrode under a 0.15 MPa argon pressure. The samples were remelted three to four time to ensure their homogeneity. Hydrogen was obtained by desorption from a LaNi<sub>5</sub>-based hydride phase. An X-ray phase analysis of alloys and hydride phases was performed in a DRON-2 diffractometer using CoK $\alpha$ -radiation with an accuracy within 0.05%. The hydrogen content was determined by the high-temperature vacuum extraction method at 1200K. The X-ray phase and differential thermal analyses of titanium-tungsten alloy hydrides reveal that as tungsten concentration increases, both the amount of absorbed hydrogen and the hydrides' heat resistance decrease. At a titanium concentration of less than 80% atomic, an alloy disproportionation accompanied by a hydride formation and a release of a tungsten-based phase was observed. References 5: 2 Russian; 3 Western; figures 2; tables 2.

#### Optical Properties of WO<sub>3</sub> Film Near Absorption Edge

917D0090D Moscow IZVESTIYA AKADEMII NAUK SSSR SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 11, Nov 90 pp 2335-2337

[Article by A. M. Solodukha, O. K. Zhukov; Voronezh State University imeni Leninist Young Communist League]

UDC 539.216.2:537.226

[Abstract] Optical properties of WO<sub>3</sub> films were examined near the absorption band edge. To this end, the dependence of the optical absorptance on the annealing temperature of WO<sub>3</sub> films produced at a room temperature by pulsed laser evaporation in a vacuum on fused quartz substrates at was investigated in the 400-700K range. An electron diffraction analysis reveals that these films are amorphous. Optical properties were studied using an SF-4A spectrometer. It is established that in amorphous WO<sub>3</sub> layers near the 3.7-4.8 eV optical absorption band edge, two transition mechanisms occur. For indirect transitions the forbidden gap width decreases from 3.40 to 2.98 eV during the transition from an amorphous to crystalline phase while in the case of direct allowed transitions the gap is about 4.0 eV wide and virtually does not change with the long-range order formation. References 8: 3 Russian; 5 Western; figures 3.

#### Effect of Boron-Containing Components on Structurization of High-Alumina Ceramics

917D0090E Moscow IZVESTIYA AKADEMII NAUK SSSR SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 11, Nov 90 pp 2406-2411

[Article by F. Ya. Kharitonov, Ye. Ya. Medvedovskiy, I. Kh. Moroz, A. F. Mironova; Elektrofarfor Scientific Production Association]

UDC 541.124-16

[Abstract] The processes and phase and structure formation of highly aluminous corundum- and mullite-type materials with various boron-containing components are examined and these components' effect on the character of these processes is investigated due to the fact that these components determine the properties of ceramic materials. To ascertain the sequence of processes occurring during the firing of the materials under study, they were fired at 1000, 1150, 1250°C, and sintering temperature. The phase composition and structure of the materials and their changes with the firing temperature were investigated by differential thermal, X-ray phase, petrographic, and electron microscope analyses. The quantitative phase analysis was performed by a radiographic semiempirical diffraction-absorption method. It is established that all materials under study have the same sequence of processes occurring in them during the firing. It is shown that the properties of high-alumina materials, namely UF-46, GM-1 and GM-1-1, GS, GD and GDTs, and GBK, depend on their microstructure and phase composition. References 12; figures 2; tables 2.

#### Phase Composition and Reduction Stability of BaTiO<sub>3</sub>-Based Ceramics

917D0090F Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 11, Nov 90 pp 2412-2417

[Article by G. D. Rubalskiy, V. K. Yarmarkin]

UDC 546.431'82:541.66

[Abstract] The effect of additions of Ga<sub>2</sub>O<sub>3</sub> and Fe<sub>2</sub>O<sub>3</sub> and the Ba:Ti ratio on the phase composition and reduction stability of BaTiO<sub>3</sub> ceramics during firing in gaseous media at low oxygen pressures is examined. Samples were synthesized using the ceramic technology by roasting mixtures of BaCO<sub>3</sub>, TiO<sub>2</sub> and Ga<sub>2</sub>O<sub>3</sub> or Fe<sub>2</sub>O<sub>3</sub> (especially high purity) allowing for the main component content and mass losses during the calcination. Disc-shaped samples with a 7-10 mm diameter and a thickness of about 1 mm were sintered in the air at 1620-1720K. The reducing firing of sintered samples lasted 1 h at 1570K in a gaseous medium at pressures between 10<sup>-3</sup> and 10<sup>-10</sup> Pa. It is shown that reduction stability of BaTiO<sub>3</sub> during firing in gaseous media at low partial oxygen pressures is determined by the ceramics' phase composition and the properties of the resulting phases. An excess TiO<sub>2</sub> 0.5% mole or more added to BaTiO<sub>3</sub> with an atomic Ba:Ti=1 ratio enters the Ba<sub>6</sub>Ti<sub>17</sub>O<sub>40</sub> phase and lowers the ceramics' electric resistance after a reducing roasting; the BaTiO<sub>3</sub> reduction stability rises with an addition of Ga<sub>2</sub>O<sub>3</sub> and Fe<sub>2</sub>O<sub>3</sub>; this is probably due to a decrease in the amount of Ba<sub>6</sub>Ti<sub>17</sub>O<sub>40</sub> phase. The ceramics' reduction stability depends on the degree of oxygen dissociation and release from the phases forming during the firing. References 17; 8 Russian; 9 Western; figures 3; tables 1.

#### Formation and Properties of Barium-Lead Titanate-Based Semiconductor Ceramics

917D0090G Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 11, Nov 90 pp 2418-2421

[Article by Yu. I. Goltsov, L. A. Shpak; Rostov State University and Physics Research Institute]

UDC 621.315.592

[Abstract] The formation and properties of barium-lead titanate-based semiconductor ceramics are studied. The liquid phase doping method is used to make ceramics with positive temperature coefficient of resistance (posistors) based on (Ba<sub>1-x</sub>Pb<sub>x</sub>)TiO<sub>3</sub> solid solutions (x=0.1-0.6); they were kicked to semiconductor state by adding WO<sub>3</sub> to PbO-B<sub>2</sub>O<sub>3</sub>-Al<sub>2</sub>O<sub>3</sub> glasses. It is shown that the use of the liquid phase doping method greatly simplifies the manufacturing technology of (Ba, Pb)TiO<sub>3</sub> solid solution-based posistors. It is shown that the optimum amount of doping additives necessary for kicking barium and lead titanate solid solutions to a semiconductor state increases with the PbTiO<sub>3</sub> composition due to a donor-acceptor compensation whereby lead titanate has a p-type conduction, so there is a partial compensation of the effect of W<sup>6+</sup> donors which substitute Ti<sup>4+</sup> ions in the crystal lattice. References 7; figures 4; tables 1.

#### Solidification of High-Strength Aluminum Alloys Under Pressure

917D0093A Moscow LITEYNOYE PROIZVODSTVO in Russian No 11, Nov 90 pp 8-10

[Article by A. I. Batyshev, V. I. Bezpalko, A. S. Lyubavin, Ye. V. Zaytsev; All-Union Polytechnic Correspondence Institute]

UDC 621.74.043.2:669.715

[Abstract] The effect of pressure on solidification, linear shrinkage, structure, and mechanical properties of AL24P and AL9M aluminum alloy castings was studied. Solidification was studied in two ways. In the first method, molten metal was teemed at 730 to 740°C into a cylindrical die 60 mm in diameter insulated with a 5 mm-thick coating of sheet asbestos to prevent the skin of the casting from growing rapidly from the direction of the die bottom and walls. The metal was then subjected to pressing forces of 65, 130, and 185 MPa from the die punch, the face of which was not insulated. This technique allowed the casting skin to grow predominantly from the direction of the punch from the moment pressure was applied. After 3.5 to 12 s, the punch was withdrawn. That part of the skin detached from the casting when the punch was withdrawn was removed and cooled to room temperature and its thickness measured. The solidification process was also studied in the conventional manner, using KTMS-KhA thermocouples

installed equidistantly from the faces of the casting and 6, 12.6, and 25 (the center) mm from the sides. Increased punch pressure decreased solidification time, but did not appreciably affect change in thickness as a function of pressing time, which is expressed by a parabolic equation. This held true for solidification both from the direction of the punch and from the direction of the die walls. Solidification under pressure produced a casting with a more fine-grained structure and improved mechanical properties, both before and after heat treatment. Linear shrinkage takes place in three stages and is inversely related to the amount of force applied and to the height to diameter ratio of the casting. Figures 4, tables 2; references 3; Russian.

#### **Effect of Rotating Magnetic Field on Degassing of Molten Aluminum Alloy**

917D0093B Moscow LITEYNOYE PROIZVODSTVO  
in Russian No 11, Nov 90 pp 13-14

[Article by A. A. Kuchayev, N. G. Rudenko; Special Industrial Design Bureau of the Institute of Electrodynamics of the USSR Academy of Sciences]

UDC 621.313.5:669.715

[Abstract] A study was done to determine how the hydrogen content of aluminum alloys would be affected by imparting a rotary motion to the molten metal during

ladle refining. The study was carried out on an experimental unit, the components and functions of which were described in detail. Molten AK7 aluminum alloy was made to rotate at a minimal speed of 21.3 radians/s around the entire capacity of the refining ladle by the interaction of the magnetic stray field of the unit's inductor windings and the alternating current (9.5 to 20 kA) passed through the metal by the unit's electrodes. A rotating magnetic field was then created by the 90° bias relative to one another in space and phase of the magnetic stray flux of the inductor windings and the magnetic flux of a detachable coil mounted on the external cylindrical surface of the refining ladle. The application of this field to the molten metal created additional torque that enabled the unit to rotate the metal at 52 radians/s. To determine the effect of the rotary motion on the metal's hydrogen content, the metal was rotated at both speeds and samples were taken immediately after the metal was teemed into the ladle and at intervals of 60, 120, and 155 minutes of rotation time. Hydrogen content was measured by melting 3 to 5 specimens in an inert gas stream on an RHIE analyzer equipped with a thermal conductivity detector. At the lower rotation speed, hydrogen content increased. At the higher rotation speed, the hydrogen content was reduced from 1.3 to 0.69 cu cm/100 g of metal after 35 minutes of rotation time. Application of this technique to technically pure aluminum reduced hydrogen content from 0.93 to 0.65 cu cm/100 g of metal and increased  $\delta$  from 2.0 to 3.4%.



**Effect of Temperature on Radiative and Optical Properties of Synthetic Ruby**

917D00664 Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 9, Sep 90 pp 1885-1888

[Article by N. S. Stelmakh, G. N. Pirogova, A. I. Ryabov, V. Ye. Kritskaya, S. P. Naselskiy, Physical Chemistry Institute at the USSR Academy of Sciences]

UDC 535.34:549.517.1

[Abstract] Radiative and optical properties of single crystals of synthetic ruby under CW and pulsed irradiation in the 77-673K range are examined and compared. It is shown that ionizing radiation causes the formation of absorption bands in the ultraviolet and visible spectra of synthetic ruby and a general growth in optical density. Ruby samples grown by the Verneuil method and containing about 0.03% Cr by mass were examined. Eight millimeter-thick slices were irradiated by  $\gamma$ -rays of  $^{60}\text{Co}$  at a rate of 8.5 Gr/s. An U-12 linac was used in pulsed electron irradiation experiments. The studies reveal short-lived absorption in ruby under the pulsed electron irradiation. It is demonstrated that the induced absorption intensity in the 200-600 nm wavelength band increases with the irradiation temperature both under a steady-state  $\gamma$ -irradiation and under pulsed electron irradiation. References 9: 6 Russian; 3 Western; figures 4.

**Investigation of Light-Fastness of Modified Zirconium Dioxide-Based Reflecting Coats**

917D0066B Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 9, Sep 90 pp 1189-1192

[Article by M. M. Mikhaylov, N. Ya. Kuznetsov, N. F. Stas, M. I. Dvoretzkiy, A. P. Aryanov, V. V. Gorbacheva, G. A. Pogrebennikov; Tomsk Polytechnic Institute imeni S. M. Kirov]

UDC 629.193.2:539.12.04

[Abstract] The effect of certain modifiers and modification methods on variations in the diffuse reflection spectra and diffuse reflectance of 9-2 superhigh-purity  $\text{ZrO}_2$  powder-based coat under irradiation by sun simulators is investigated. The light-fast pigment was modified either with  $\text{Sr}(\text{NO}_3)_2$  and  $\text{SrSiO}_3$  or silicon dioxide. Coat samples were prepared by mixing pigment powders with a polymethylsiloxane binder in a ball mill in a 3:1 ratio with subsequent application on a metal substrate. It is established that by modifying  $\text{ZrO}_2$  powder with a monolayer of 9-2 superhigh-purity  $\text{SiO}_2$  considerably increases the light-fastness of coats made on the basis of this pigment under ultraviolet irradiation due to the formation of a protective film on the pigment particle surface. A significant albeit smaller improvement in light-fastness is also attained by modifying zirconium dioxide with  $\text{SrSiO}_3$ . It is shown that modification with

$\text{Sr}(\text{NO}_3)_2$  does not lead to a noticeable improvement in the light-fastness of coats. References 16: 13 Russian, 3 Western; figures 3.

**Role of Impurity Iron Atoms in Silicon Nitride Ceramics**

917D0066C Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 9, Sep 90 pp 1956-1958

[Article by Ye. A. Tomiltsev, L. V. Kozlovskiy, D. V. Grabezhev, V. V. Kutasov; Leningrad Technological Institute imeni City Council]

UDC 666.3

[Abstract] Silicon nitride powder containing 0.32% of iron and 0.06% free silicon by mass with magnesium and aluminum oxide as sintering activator was examined. Mixtures were reduced in a nonlined vibratory mill with the help of refractory balls. The resulting silicon nitride- $^{57}\text{Fe}$ , silicon nitride- $\text{Al}_2\text{O}_3$ - $^{57}\text{Fe}$ , and silicon nitride- $\text{MgO}$ - $^{57}\text{Fe}$  system ceramics are examined by the nuclear gamma resonance method. The mixture was carefully stirred, molded into tablets, and sintered in a nitrogen atmosphere for 1 h at 1750°C.  $^{57}\text{Co}$  was used as a radiation source. Nuclear gamma resonance spectra show that iron silicides form in the last system. In the case of the first two systems, the principal amount of iron is arranged in the silicon nitride lattice in an atomic form and appears as a single line with a zero chemical shift in both samples. References 4: 3 Russian, 1 Western; figures 2.

**Impurity Diffusion in Modified Lead Zirconate-Titanate Ceramics**

917D0066D Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 9, Sep 90 pp 1964-1966

[Article by M. V. Slinkina, G. I. Dontsov, V. M. Zhukovskiy, R. R. Khafizov; Urals Polytechnic Institute imeni S. M. Kirov]

UDC 539.219.3:621.315.4

[Abstract] Diffusion parameters of modifying impurities—heterovalent ions of various metals—in lead titanate-zirconate ceramics (TsTS) with additions of niobium and strontium and 1%  $\text{Nb}_2\text{O}_5$  by mass are examined with the help of  $^{48}\text{V}$ ,  $^{51}\text{Cr}$ ,  $^{54}\text{Mn}$ ,  $^{65}\text{Zn}$ ,  $^{90}\text{Sr}$ ,  $^{90}\text{Y}$ , and  $^{95}\text{Nb}$  radioactive nuclides in the 600-1000°C temperature range. The samples were produced by sintering at a  $3 \times 10^7$  Pa pressure at 1280°C. The layer-by-layer radiometry method was used. The experiments revealed a high diffusion mobility of  $^{48}\text{V}$ ,  $^{51}\text{Cr}$ ,  $^{54}\text{Mn}$ ,  $^{65}\text{Zn}$ ,  $^{90}\text{Sr}$ ,  $^{90}\text{Y}$ , and  $^{95}\text{Nb}$  impurities in the  $\text{Pb}_{0.95}\text{Sr}_{0.05}(\text{Ti}_{0.47}\text{Zr}_{0.53})\text{O}_3$  ceramic. The authors are grateful to V. A. Golovnin for providing samples of TsTS ceramics. References 2; figures 2; tables 1.

**GaAs Heavily Doped With Beryllium Produced by Molecular Beam Epitaxy**

917D0066E Moscow IZVESTIYA AKADEMII NAUK SSSR SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 9, Sep 90 pp 1977-1978

[Article by K. S. Zhuravlev, D. I. Lubyshev, V. P. Migal, V. V. Preobrazhenskiy, S. I. Stenin, S. A. Terekhov; Semiconductor Physics Institute at the Siberian Branch of the USSR Academy of Sciences]

UDC 621.315.592:539.216:535.376

[Abstract] The effect of growth conditions of highly doped GaAs<Be> on the formation of deep-lying states (GU) is examined. Films were grown in an upgraded PMA-12 MBE (MLE) unit. Semiconductor GaAs<Cr> (100) slices were used as the substrate. A buffer layer of nondoped GaAs and then a GaAs<Be> layer were grown on the atomically pure substrate surface at 450°C at a 1 μm/h rate. The growth condition was monitored by fast electron diffraction while pressure in molecular flows was measured by an ionization manometer whose sensor was placed in the growth zone. It is shown that production of GaAs films by the MBE method under conditions which ensure a stoichiometric growth surface composition leads to a disappearance of low-lying states in the 1.15-1.45 eV energy band given a beryllium doping of up to  $4 \times 10^{20} \text{ cm}^{-3}$  with a simultaneous increase in the total photoluminescence intensity at 300K. References 6: 2 Russian, 4 Western; figures 2.

**Electrophysical Properties of New  $\text{Li}_2\text{B}_4\text{O}_7$  Superionic Crystal**

917D0066F Moscow IZVESTIYA AKADEMII NAUK SSSR SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 9, Sep 90 pp 1991-1993

[Article by A. E. Aliyev, Ya. V. Burak, I. T. Lyseyko; Thermal Physics Department at the Uzbek Academy of Sciences]

UDC 538.931

[Abstract] Measurement data on the conductivity, dielectric constant (adiabatic dielectric constant at constant stresses along the polar axis), and dielectric loss tangent of single crystal samples of lithium tetraborate (TBL) in the  $10^2$ - $10^5$  Hz frequency and 100-600K temperature ranges are described. Crystals were grown by Czochralski's method in platinum crucibles from stoichiometric compositions in the air. Prior to measurements, all samples were annealed at 500K in a nitrogen atmosphere after which their parameters were determined by standard techniques. Experimental data are consistent with theoretical values at a 100 Hz frequency and 350K temperature. It is shown that the high dielectric constant of TBL at low frequencies is determined to the mechanism of thermal ion polarization due to weakly coupled lithium ions while  $\text{Li}_2\text{B}_4\text{O}_7$  single crystals themselves

can be regarded as unidimensional superion conductors which belong to the same group as  $\text{LiAlSiO}_4$ ,  $\alpha\text{-LiIO}_3$ , etc. References 7: 3 Russian; 4 Western; figures 3.

**On Character of Breakdown of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ -Based High-Temperature Ceramics**

917D0066G Moscow IZVESTIYA AKADEMII NAUK SSSR SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 9, Sep 90 pp 1995-1993

[Article by I. S. Semirikov, T. F. Telnykh, Ye. A. Nikonenko, A. V. Vostretsova, A. K. Sholtis; Urals Polytechnic Institute imeni S. M. Kirov]

UDC 542.9

[Abstract] A case of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ -based high-temperature superconducting ceramics breakdown during firing under the effect of high temperatures in the presence of butanol vapors is described. Thermographic, thermal gravimetry, infrared spectroscopy, and X-ray phase analyses methods were used to study this complex oxide compound in the presence of butanol vapors ( $\text{C}_4\text{H}_9\text{OH}$ ) at 260°C. Experiments reveal that destruction is caused by the presence on the surface of particles of residual butanol whose burnout leads to the breakdown of the superconducting ceramics. It is shown that the high- $T_c$  material is highly active (explosible) with butanol at this temperature. Moreover, the complex oxide completely breaks down into its original components with a simultaneous reduction of copper ions to  $\text{Cu}^+$  and  $\text{Cu}^0$ . It is demonstrated that infrared spectroscopy data confirm the results of X-Ray phase and thermal gravimetry analyses attesting the superconducting ceramics breakdown direction. References 5; figures 1.

**Phase Transitions in  $\text{Bi-Bi}_2\text{O}_3\text{-GeO}_2$  System**

917D0066H Moscow IZVESTIYA AKADEMII NAUK SSSR SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 26 No 9, Sep 90 pp 1986-1987

[Article by G. S. Suleymenova, V. M. Skorikov; General and Inorganic Chemistry Institute imeni N. S. Kurnakov at the USSR Academy of Sciences]

UDC 541.123.7

[Abstract] To explain the development stable and metastable phases in  $\text{Bi}_2\text{O}_3$ -based systems, phase ratios and transitions in a  $\text{Bi-Bi}_2\text{O}_3\text{-GeO}_2$  system were examined. The original compounds were synthesized by sintering stoichiometric quantities of  $\text{Bi}_2\text{O}_3$  and  $\text{GeO}_2$  (99.99% pure by mass) in the air at 850, 950, and 920°C. Three-phase samples under study were synthesized from a mixture of high-purity bismuth or germanium with bismuth and germanium oxides by annealing in a vacuum and subsequent hardening. The phase composition was

examined by differential thermal analysis using a Geigerflex diffractometer. The results obtained in the experiment make it possible to explain peculiarities of the bismuth germanate behavior; they show that since  $\text{Bi}_2\text{Ge}_3\text{O}_9$  is stable only above  $750^\circ\text{C}$ , there is no thermodynamic prohibition on its crystallization yet it becomes complicated by kinetic factors. Below  $750^\circ\text{C}$  for

compositions close to  $\text{Bi}_2\text{Ge}_3\text{O}_9$ , only two mixtures are stable:  $\text{Bi}_4\text{Ge}_3\text{O}_{12}$  and  $\text{GeO}_2$  (tertiary). These factors make the crystallization of the aforementioned phases possible in the case of supercooled samples as well as explain the fact that  $\text{Bi}_2\text{Ge}_3\text{O}_9$  is not formed under hydrothermal conditions at  $300\text{--}450^\circ\text{C}$ . References 4: 2 Russian; 2 Western; figures 1; tables 1.

### Developing Stressed Hard Alloy Upsetting Die Structures by Plastic Shrouding Method

917D0073A Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 9, Sep 90 pp 7-9

[Article by V. A. Kaskov]

UDC 621.73.073.002.3:669.018.25

[Abstract] Issues of ensuring the performance of hard alloy upsetting dies by developing stressed structures by means of cold or hot press-fitting of hard alloy inserts forming a shroud into each other and their disadvantages are considered. A new method often referred to as plastic shrouding developed at the Volga branch of the Orgprimverdostav Special Design Office for making stressed hard alloy die structures, primarily for upsetting dies for taper bearing rollers is examined. An analysis of the method shows that it supplies die tools with high performance qualities and substantially expands design and technological possibilities for developing hard alloy tools. In addition, theoretical relations necessary for designing shrouding parameters are derived and recommendations for selecting design specifications are proposed. The guaranteed annual economic impact from implementing hard alloy die shrouding for upsetting conical rollers for eight standard taper bearing sizes is about 120,000 rubles. V. A. Shmelev, V. N. Guzhva, A. D. Savin, E. F. Larina, A. I. Nazarenko, and Ye. I. Berezutskiy participated in the study. References 3; figures 4.

### Experimental Investigation of Cold Extrusion of Tungsten Powder Billets

917D0073B Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 9, Sep 90 pp 15-18

[Article by S. A. Mymrin, V. E. Kuznetsov, L. A. Barkov, S. A. Leonov, M. L. Yampolskiy]

UDC 621.777.01:669.277.02

[Abstract] The results of a comprehensive commercial investigation of cold extrusion of billets from various types of tungsten powders for the purpose of predicting the resulting density characteristics are cited. Finely dispersed VCh and VA tungsten powders with a bulk density of 4.29 to 5.18 t/m<sup>3</sup> of the former and 2.24 to 2.83 t/m<sup>3</sup> of the latter were used in the studies. The results of these multifactor commercial experiments of cold extrusion of long VCh and VA tungsten powder billets in parting metal molds are processed with the help of mathematical statistics methods are presented in the form of a system of regression equations. The solution of this system by numerical methods on a computer made it possible to determine the optimal mass of the tungsten powder batch and the specific compaction pressure at a given powder bulk density, billet density, and billet

dimensions (height). A computer printout is made indicating actual billet density ranges. In addition, alignment charts are plotted for calculating billet compaction parameters under industrial conditions. L. G. Kabakova, A. N. Dementyev, V. D. Shepelev, and N. N. Agafilushkina participated in the study. References 12; 10 Russian; 2 Western; figures 3; tables 4.

### Status and Development Outlook of Electric Hydroimpulse Plastic Metal Working

917D0072A Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 8, Aug 90 pp 2-4

[Article by B. Ya. Mazurovskiy, Electric Hydroimpulse Working Council]

UDC 621.983.044.4.001

[Abstract] Recent publications in the field of electric hydroimpulse plastic metal working (EG) are surveyed. It is shown that during EG periodic elastic waves of mechanical stresses form in the materials; these waves are capable of retarding microfailures and increasing the ductility resource due to a release of dislocations from clusters and lead to an increase in the elongation, percentage reduction of area, and uniform straining as well as a decrease in the residual stresses and an increase in corrosion resistance. New designs of EG equipment are described and the results of EG equipment tests are presented. It is stressed that EG equipment for press-fitting tubes into heat exchanger tube plates is successfully operating at nuclear power plants in the USSR, Finland, eastern Germany, Bulgaria, and Cuba. Devices for automatic control of energy parameters of EG during the tube press-fitting are summarized. The efficacy of tube press-fitting by EG methods is compared to that of conventional expanding and flaring methods. A process of diffusion welding of tubes into tube plates developed on the basis of electric explosion pressure is described. Plans for expanding technological capabilities of the method and priorities of its implementation are outlined. References 12; figures 4.

### Intensification and Improvement of Closed-Die Forging of Iron Powder Parts

917D0072B Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 8, Aug 90 pp 4-6

[Article by A. M. Dmitriyev]

UDC 621.777.4

[Abstract] Among a wide diversity of powder parts manufacturing methods, cold extrusion of parts from caked powder blanks and cold molding of powders in a closed die with subsequent caking lend themselves best to intensifying and improving the production output. It is shown that applications of cold extrusion of parts in



one pass from caked powder blanks can be expanded by using extrusion methods with active contact frictional forces; these forces can be manipulated in order to control the quality of parts. A process of making deep liners by extruding them from caked powder blanks is designed and analyzed. As a result, methods of selecting optimum process parameters are developed and tested. It is recognized that better results are obtained in molding rings from the ULTRAPAC-LE powder manufactured by the Mannesmann Demag company than by using domestic homogeneous alloyed powders. Studies show that in molding thin-walled bushes using active frictional force at the point of powder contact with the mandrel, a 95% relative density can be attained in the thinnest bush cross section. Thus, production processes of high-strength rings, bushes, and liners from iron-based powders have been developed and prototypes of specialized presses and dies for making these parts have been developed and successfully tested. References 6; figures 7.

#### **Casting and Forging Complexes: New Trend in Developing Press and Die Forging**

917D0072C Moscow  
KUZNECHNO-SHTAMPOVOCHNOYE  
PROIZVODSTVO in Russian No 8, Aug 90 pp 7-8

[Article by S. P. Burkin, Ye. A. Korshunov, G. V. Mironov]

UDC 621.73.043

[Abstract] It is shown that the need to begin the development of highly efficient automatic modules for making a wide assortment of forgings without retooling is prompted by a new trend in machine building - small batch or even custom production. The task of developing computer-aided and automatic equipment for plastic metal working (OMD) in custom and small batch production which can be adapted to the production technology of a wide range of machine tool parts without using robots and auxiliary fittings and without retooling and makes it possible to utilize all modern achievements in the field of plastic forming is outlined. It is shown that due to its modular structure and adaptive control, new methods and operations can be utilized in such equipment and combined in the framework of a single CAD/CAM software thus eliminating paperwork and ensuring a wide selection of efficiency functions. In particular, new metal working centers (OTs) can be developed for making a wide range of parts under small batch and custom production conditions. New casting and reduction complexes which combine continuous casting machines (MNLZ) with OTs for making small forgings are described and their advantages are summarized. It is demonstrated that the new technology leads to a much better forging metal quality. References 6.

#### **Robot-Assisted Self-Propelled Hoisting and Moving Platform**

917D0072D Moscow  
KUZNECHNO-SHTAMPOVOCHNOYE  
PROIZVODSTVO in Russian No 8, Aug 90 pp 34-35

[Article by N. V. Potekushin, F. A. Krasin]

UDC 621.771:621.865

[Abstract] A robot-assisted self-propelled hoisting and transporting platform designed, built, and tested at the Chelyabinsk Acrylic Glass Works is described. The walking platform does not need tracks and can be used for loading and unloading containers and cars and for servicing transfer stations and packaging areas. The purpose and design execution of the platform are determined by three groups of interdependent parts: the running gear combined with the base, a load-carrying U-shaped tray, and intermediate bearing and guiding rollers. The sequence of operations performed by the platform is described. It is demonstrated that the platform has a simple design and is transportable; it ensures smooth operation of the hoisting mechanism and cargo manipulation mechanism, has a low mass, and is maneuverable. The platform's economic impact from just eliminating manual operations is over 122,000 rubles a year; the expediency of using the platform has been confirmed by many years of its operation at the plant. References 3; figures 2; tables 1.

#### **Robot-Assisted Forging Roll-Based Production System**

917D0072E Moscow  
KUZNECHNO-SHTAMPOVOCHNOYE  
PROIZVODSTVO in Russian No 8, Aug 90 pp 35-36

[Article by V. Ye. Yakovlev, A. M. Ryabov]

UDC 330.341.4:621.865.8

[Abstract] A robot-assisted production system (RTK) for forge-rolling blanks for their subsequent forging developed and implemented by the Taganrog Research and Design Institute of Die Forging together with the Ukrainian Branch of the Aviation Technology Institute is described. The advantages of the industrial robot (PR) contained in the new RTK over existing PR include an absence of a mechanical linkage between the PR arm drive and roller drive. The RTK components and their manufacturers are summarized and its operating principle is described in detail. The RTK consists of an industrial robot developed and manufactured by the PKTikuzrobot, a blanks loading mechanism developed and manufactured by the PKTikuzrobot; forging rolls S1335 developed and manufactured by the Voronezh Production Association of Forge and Die Plant Equipment imeni M. I. Kalinin; and a heating device developed by the Ukrainian Branch of the Aviation Technology Institute in Kiev. Principal specifications of

model K50.837 RTK are cited. The RTK was implemented at the Tashkent Aviation Production Association imeni V. P. Chkalov in 1988. Figures 1; tables 1.

### Problems of Intensifying Hot Plastic Working Processes

917D0071A Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 7, Jul 90 pp 3-5

[Article by O. A. Ganago, All-Union Scientific-Technical Mechanical Engineering Society]

UDC 621.73.001

[Abstract] Possible trends in improving the methods and processes of hot plastic metal working are considered from the viewpoint of accelerating the scientific and engineering progress by switching from an evolutionary path of development to a revolutionary one based on new concepts which are capable of leading to structural changes both in the physical production and social spheres. The following possibilities are addressed: developing an alternative method of making blanks for machine parts; using new types of original blanks; modifying temperature conditions of plastic forming; developing new mechanical principles of forming; using forming by means of active effect of frictional forces; and developing standard technologies. Examples of implementation of the proposed measures are cited. It is expected that the development of new specialized standard technologies will raise the technical level of parts manufacturing for the domestic market and for export. References 18.

### Development of Superplastic Deformation Process Theory and Technology

917D0071B Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 7, Jul 90 pp 6-8

[Article by O. M. Smirnov, Superplasticity Council]

UDC 621.61.01

[Abstract] Attempts to examine, develop, and optimize the processes of superplastic forming (SPF) carried out in the USSR and abroad are considered. Principal science research efforts of the past five years aimed at developing scientific principles of plastic metal working (OMD) in the superplasticity state and developing a theory of new processes are summarized. Studies of superplastic material forming mechanics, rheological behavior patterns of alloys with ultrafine grains, research and development of superplastic forming (SPF) processes, examinations of isothermal forging in the superplasticity state, and issues of structural ceramics are described. It is shown that today, superplastic forming is the only method of producing stamped parts with a complex shape from structural ceramics which makes it

possible to remove pores in the material structure and improve the performance of products. References 7: 6 Russian, 1 Western; figures 2.

### Priority Trend in Improving Production of Precision Short Blanks From Bar Stock

917D0071C Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 7, Jul 90 pp 8-11

[Article by S. S. Solovtsov, N. L. Lisunets]

UDC 621.96.002.22

[Abstract] Trends in improving and developing the production of parts from bar stock using comprehensive billeting and sorting processes (KZRP) whereby simple shear cutting processes are combined with plastic forming are summarized. A new concept is suggested and developed for producing short blanks from bar stock for today's computer-aided manufacturing; in essence, the shape, dimensions, and surface quality of blanks being made must be prepared so as to be suitable for subsequent machining processes. To this end, it is recommended that that comprehensive billeting and sorting processes be used in order to ensure manufacturing of precision-volume blanks with rounded edges and bevels as well as end markings from standardized bars. Comprehensive processes are classified and investigated and methodological principles of their computer-aided design and standard die designs are developed. References 2; figures 3; tables 2.

### Principal Electromagnetic Working Development Trends

917D0071D Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 7, Jul 90 pp 11-12

[Article by V. A. Glushchenkov]

UDC 621.983.044.7.001

[Abstract] It is noted that successful development of electromagnetic machining calls for combining the efforts of the country's relevant science and engineering entities in the framework of the electromagnetic machining section at the Scientific Council of the USSR State Committee on Science and Technology and the USSR State Planning Board. The progress and shortcomings in this field are noted. The following principal trends are identified by the Section and Coordinating Committee: developing a package of processes to make parts and assemblies from composite materials; designing processes, equipment, and induction systems for making consumer goods; further advancing efforts on electromagnetic working efforts in the framework of the comprehensive science and engineering progress program of COMECON member-countries; developing robot-assisted sets for electromagnetic forming of sheet

and tubular blanks; developing repair and erection technologies for special conditions and specialized tools for their realization; preparing for and producing standards and manuals; developing new electromagnetic working methods and ensuring their pilot assimilation; and examining the effect pulsing magnetic fields on humans and establishing maximum permissible doses of such exposures. References 3.

#### Ways of Improving Pressing out of Relief Cavities

917D0071E Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 7, Jul 90 pp 13-14

[Article by A. I. Hibemjagi]

UDC 621.777.01.001

[Abstract] Processes of making relief cavities and other equipment by extrusion distinguished by a high quality and accuracy of relief surfaces as well as the identity of complex relief cavities due to the constancy of forming shape and dimensions of the master punch are reviewed. The experience of domestic plants and foreign publications which show that the use of rigid plastic clamps, extrusion methods with relief flaring and radial crimping, and hot and semihot extrusion methods should be expanded are summarized. Ways of increasing the dimensional accuracy of extruded cavities, pressing out by relief flaring, and radial reduction are discussed. The master punch design and pressing out of clad metal matrices as well as the gamma extrusion presses are described. The technical and economic advantages of extrusion of relief cavities compared to electric discharge machining are cited. The parameters of cold embossing of relief cavities with a high indentation pressure used at Tallinn plants are summarized. References 6: 5 Russian, 1 Western; figures 2; tables 2.

#### Expanding Technological Capabilities and Improving Efficacy of Hot and Semihot Die Forging Processes

917D0071F Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 7, Jul 90 pp 14-17

[Article by V. A. Golovin, Cold Forging Committee]

UDC 621.73.016.001.2

[Abstract] Ways of expanding technological capabilities and improving the efficacy of billeting by cold, semihot, and hot die forging - a priority trend in machining, metallurgy, and mechanical engineering - are summarized. The state of efforts in this field is evaluated. The issue of controlling the technological deformability and quality of forged blanks and the role of the scale factor are addressed. A methodology is suggested for solving urgent production tasks using a multicriterial design and technological classifier. The classifier can serve as the

basis for standardizing technologies and tools, improving practical feasibility of part designs, increasing the technical level of equipment, and employing computers in the production tooling process. References 9; figures 2; tables 1.

#### Making High-Proof Forging Dies by Precision Casting Methods

917D0071G Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 7, Jul 90 pp 21-24

[Article by A. V. Orlov]

UDC 621.73.073:621.74.04

[Abstract] The experience of manufacturing and operating cast forging dies is summarized. It is shown that due to its actual technical and economic advantages, in the next 5-10 years the precision casting method of making dies will become dominant in the production of a broad range of dies and casting and metallurgical equipment such as metal molds, chills, extrusion dies, etc. According to expert estimates of the forging and tool making industries, up to 75% of all forging equipment used for making hot forgings can be made by the casting method. Depending on the specific conditions, a wide range of casting methods can be used for this purpose, from casting into precision ceramic, metal, and sandy molds to investment molding. Casting into temporary block molds made from thermosetting mixtures is the most promising process which meets today's technological standards and is characterized by its simplicity, versatility, and economy as well as its absence of waste. The process can be used for making upsetting, forging, trimming, and other dies. This process may become a priority in the manufacturing forging, casting, and metallurgical equipment in the near future. References 6; figures 3.

#### Conditions and Range of Problems of Forming Thin-Walled Parts by Elastic Medium in Rotary Machines

917D0071H Moscow

KUZNECHNO-SHTAMPOVOCHNOYE

PROIZVODSTVO in Russian No 7, Jul 90 pp 24-27

[Article by I. M. Zakirov]

UDC 621.981.2.001

[Abstract] A new trend which characterizes the development of highly efficient technologies, the use of original rotary machines in which an elastic material serves as forming elements, is considered. In essence, forming by elastic medium in a rotary machine amounts to successive local continuous deforming of the billet by an elastic medium in a rotary machine between molding elements at least one of which has an axis of rotation. In particular, bending, forming to shape, forming, cutting, and a

combination of these operations are examined. Various types of forming of sheet, section, and tubular parts are described. The problems of stresses developing during the cutting and forming are addressed. The outlook for using machines with numerical control is considered. References 5; figures 10.

#### **Conditions Development Outlook for Forge and Die Plant Production**

917D00711 Moscow  
KUZNECHNO-SHTAMPOVOCHNOYE  
PROIZVODSTVO in Russian No 7, Jul 90 pp 27-28

[Article by A. I. Petrov, I. M. Podrabinnik]

UDC 621.97.001

[Abstract] Shortages of forge and die equipment and the poor technical level of individual pieces of equipment are identified. The outlook for the development of forge and die plant production is considered and a wide range of measures aimed at producing precise blanks and ready products are outlined. A number of new types of forge and die equipment necessary for using metals powders, ceramics, plastics, and scrap metal is summarized. The state of efforts aimed at solving the existing problems is described. Recommendations are made for increasing the production of hydraulically driven and numerically controlled equipment. Special attention is focused on producing automatic systems and machines; a high priority is given to automatic production lines for meeting social needs of the population, i.e., producing bathtubs, sinks, washers, car parts, and electrical appliances. A trend toward specialized equipment for large-scale and small-batch production and concentration of a large number of operations in one machine, as well as modular designs is identified. It is shown that today, enterprises of the USSR Ministry of Machine Tool Building are incapable of ensuring the necessary development of advanced forge and die equipment and that enterprises of the defense and local industries must be drawn into the process.

#### **Alloying Element Losses During Corrosion-Resistant Steel Smelting**

917D0070A Moscow IZVESTIYA VYSSHIKH  
UCHEBNYKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 10, Oct 90 pp 17-20

[Article by G. O. Neygebauer, R. A. Gizatulin, M. B. Orzhekh; Siberian Metallurgy Institute and Kuznetsk Integrated Iron and Steel Works]

UDC 669.187:669.015.9

[Abstract] Losses of alloying additions during the smelting of steel 08-12Kh18N10T are considered. Quantitative data on the total losses of nickel and chromium are obtained in order to select efficient ways of reducing total losses. As a result, a balance of chromium and

nickel losses during the smelting of corrosion-resistant steel is calculated. It is shown that the loss of alloying additions from the furnace in the form of effluent gases is insignificant compared to total losses. On the other hand, losses with slag in the form of metallic scrapings and shots are high and equal to up to 96% of total losses for nickel and up to 35% for chromium. Given a single-slag smelting technology, this type of losses is several times lower than that of the two-slag method. It is emphasized that special attention must be given to utilizing all reserves in order to decrease metal losses during the smelting and casting of steel. References 3; tables 4.

#### **Systems Approach to Developing Methods of Producing Slabs From Slab Ingots**

917D0070B Moscow IZVESTIYA VYSSHIKH  
UCHEBNYKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 10, Oct 90 pp 29-30

[Article by V. M. Klimenko, Yu. I. Yurchenko, D. V. Sinitsin, E. L. Filippov; Donetsk Polytechnic Institute]

UDC 621.771.23

[Abstract] A range of factors which fully take into account the entire process of ingots production and their subsequent rolling in plate mills is considered in order to find reserves for reducing consumption coefficients. The systems approach method is used to solve this problem; in so doing, a block diagram model of the production process of thick plates and slabs from ingots is constructed whereby interactions between blocks are characterized by logical relations. As a result, a complex of factors which determine the loss of metal during the production of plate stock using slab ingots as the source material is classified. An additional area is identified for searching for reserves for decreasing the specific metal consumption of the process. It is shown that the necessary quality and shape of original blanks may be attained by including the forging stage into the process. Certain reserves can be found by using oriented ingot crystallization in the ingot mold. References 4; figures 1.

#### **Elastic Wave Propagation in Materials With Disturbed Continuity**

917D0070C Moscow IZVESTIYA VYSSHIKH  
UCHEBNYKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 10, Oct 90 pp 34-37

[Article by V. I. Petrov, V. D. Sarychev, M. V. Kavlakan, N. A. Chelyshev; Siberian Metallurgy Institute]

UDC 621.77.001.2

[Abstract] An attempt is made to substantiate theoretically the elastic wave propagation in a material whose continuity is being disturbed. A plane problem of emission of waves by a moving crack perpendicular to the free surface of a prestressed material is considered as a



mathematical model of the phenomenon. Two cases are considered: an infinitely short crack and an infinite free surface and a semi-infinite crack. The problem formulation is reduced to determining in a first approximation the field of elastic stresses and displacements which satisfy given boundary value conditions. As a result, the problem of wave emission by a moving crack perpendicular to the free surface is reduced to finite expressions in terms of Fourier transforms. It is shown that a numerical result can be obtained on a computer. References 6: 5 Russian; 1 Western; figures 1.

### Dispersion Degree and Magnetic Properties of Microcrystalline Alloys of Highly Anisotropic Magnetics

917D0070D Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 90 pp 39-40

[Article by N. A. Manakov, Irkutsk State Teachers College]

UDC 669.046:538.2:621.318.12

[Abstract] To identify general patterns in the magnetic field variations as a function of the dispersion degree of magnetics produced by liquid phase quenching or gaseous phase precipitation, well-known  $\text{SmCo}_5$  alloy films and quenched alloys are examined. Changes in hysteresis characteristics and domain structure as well as other magnetic properties of these materials are investigated. Special attention is given to alloys of highly anisotropic magnetics. The character of coercive force, remanent relative magnetization, and domain size variations as a function of crystal grain size of isotropic  $\text{SmCo}_5$  alloys is analyzed. It is shown that changes in magnetic parameters of isotropic alloys of highly anisotropic magnetics produced by liquid phase quenching or gaseous phase precipitation as a function of the dispersion degree follow a predictable pattern and can be tentatively divided into five groups: domain wall displacement (thrice), rotation, and nucleation. References 12: 8 Russian; 4 Western; figures 1; tables 1.

### Chromizing and Titanizing of Powder Hard Alloys

917D0070E Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 90 pp 40-41

[Article by Yu. N. Gromov, N. Ya. Kudryavtseva, V. V. Kotlyarov; Kemerovo Food Processing Technology Institute]

UDC 669.046:621-758

[Abstract] Protective layers obtained by simultaneously saturating the VK-6 hard alloy with two carbide-forming elements - chromium and titanium - in order to increase its scaling, corrosion, wear, and cavitation resistance are

examined. Hard alloy 12x12x14.5 mm plates were saturated by the powder method using special airtight containers with a fusible lock at 1000°C for 4-6 h. The resulting coats' microstructure was analyzed under a MIM-8 metallographic microscope. The samples were etched by a Murakami agent. Microhardness was measured by a PMT-3 microhardness gauge. The phase analysis was carried out in a DRON-3 diffractometer in copper radiation by a layer-by-layer analysis. It is shown that the diffusion layer formation on the VK-6 alloy during its simultaneous saturation with chromium and titanium occurs in the following sequence: first titanium carbides are formed, then chromium carbides, at the same time, carbon is depleted from the base and complex carbides with the  $\text{Co}_3\text{W}_3\text{C}$  and  $\text{Co}_6\text{W}_6\text{C}$  composition are formed in the transition zone. The diffusion layer formation mechanism can be explained on the basis of the characteristic features of the saturating elements' atomic structure. References 7; figures 3

### Characteristics of Metal and Alloy Crystallization During Laser Processing

917D0070F Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 90 pp 42-44

[Article by V. B. Babushkin, L. G. Voroshin, V. V. Parkhimovich; Belorussian Polytechnic Institute, Minsk]

UDC 669.046:621.785.545

[Abstract] Peculiarities of crystallization of metals melted by laser irradiation are examined in order to resolve contradictory data of various researchers on the crystallization mechanics of such layers. It is shown that the layer melted by laser irradiation crystallizes on a seed; partially fused base metal grains often serve as such a seed. In the case where the material has a single-phase structure at the start of melting, the grain's transverse size in the fusing zone corresponds to the grain size in the heat-affected zone. As a result, there is a direct correlation between the fusing zone structure and the material's initial state. The crystallite length is related to the dimensions and shape of the fusing zone; crystal grains in this zone maintain the crystallographic orientation of the seed grain, i.e., epitaxy occurs during the molten layer crystallization. References 8: 6 Russian, 2 Western; figures 3.

### Effect of Heat Treatment on Microstructure and Cavitation Erosion of Aluminum Cast Iron

917D0070G Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 90 pp 46-48

[Article by Yu. G. Bobro, A. Yu. Bobro; Casting Problems Institute at the Ukrainian Academy of Sciences, Kiev]

UDC 669.137.669.15:71-196-15

[Abstract] The possibility of using aluminum-alloyed pig iron for making castings exposed to cavitation erosion during their operation is examined. To this end, aluminum pig iron with globular graphite containing 3.30% C, 1.45% Si, 0.8% Mn, 2.3% Al, 0.45% Ni, 0.26% Cr, 0.23% Ti, 0.02% P, 0.01% S, and 0.05% Mg was investigated. Cast iron samples were selected from a large batch of smeltings by means of positive estimates of smoothed mechanical parameters and casting characteristics. The selection of chemical composition was based on an assumption that silicon substitution with aluminum decreases the brittle state in cast iron due to the advantages of Fe-Al metallic bonds in place of brittle Fe-Si bonds. An analysis of the resulting data shows that aluminum cast iron with globular graphite has an increased tendency toward viscous failure under discrete mechanical loading. In addition, the relationship between the parameters determined by the comprehensive nonuniform compression method and failure processes during the cavitation erosion is ascertained and an indirect relationship between the microstructure of aluminum cast iron after heat treatment and hydroerosion is established. The outlook for using these types of cast iron for making centrifugal pump turbine wheels is determined. References 5: 4 Russian; 1 Western; figures 1, tables 1.

#### Production of Composite and Combined Castings

917D0069C Moscow IZVESTIYA VYSSHIKH  
UCHEBNYKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 9, Sep 90 pp 74-76

[Article by S. S. Shpindler, R. F. Mamleyev, M. I. Landa (deceased), V. B. Bogatyrev; Ufa Aviation Institute]

UDC 621.746/747

[Abstract] The design of a new furnace assembled in the prechamber of the UPPF-3 vacuum smelter instead of a standard one developed for producing high-quality combined castings with a molding surface from a composite material which represents a titanium carbide frame sintered in a vacuum and impregnated with the ZhS6U high-temperature alloy as well as composite die castings is described. It is shown that the main advantages of the device for making composite and combined castings include the possibility of controlled preheating of the cermet composite insert to a 500-1200°C temperature which eliminates their fracture from a temperature shock during the casting process; the possibility of exposing the molten metal in the mold during a given time to any desired temperature thus making it possible to control the forming of a high-quality metal-composite material joint as well as obtain composite castings with a guaranteed high-quality bonding of two alloys. Figures 2.

#### Phase Composition of Silicomanganese-Based Complex Alloys Containing Aluminum and Titanium

917D0069A Moscow IZVESTIYA VYSSHIKH  
UCHEBNYKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 9, Sep 90 pp 63-67

[Article by M. I. Gasik, V. G. Myachin, O. I. Polyakov, A. N. Kurasov; Dnepropetrovsk Metallurgy Institute]

UDC 669.046.554:669.15-198

[Abstract] Phase components of silicomanganese-based complex alloys containing aluminum and titanium is analyzed. The problem is formulated from the viewpoint of ascertaining the stabilization mechanism and determining the concentration regions which correspond to compositions of failure-resistant alloys of the Mn-Si-Al-C-Ti-P system. The microstructure of commercial silicomanganese without aluminum or titanium was determined by etching in a boiling 30% sodium bicarbonate solution while that of the remaining aluminum- and titanium-containing alloys by thermal etching of samples. The phase composition was determined by metallographic, X-ray structural, and X-ray spectral analyses. These analyses reveal that the principal structural component of all alloys containing 0-10% aluminum and 0-5% titanium is Nowotny's phase  $Mn_3Si_4(C_2)$ . As the aluminum content increases, carbon-containing phases are transformed in the  $Mn_3Si_4C_2 - Mn_3AlC_4 - Al_4C_3$  sequence. It is established that the mechanism of titanium-stabilization of alloys containing >3% aluminum amounts to the binding of carbon into a titanium carbide chemically stable to moisture. Concentration regions which correspond to the composition of complex alloys resistant to self-friability are determined. It is suggested that due to the inevitable aluminum, carbon, and titanium segregation, titanium be added during the production of said alloys in a  $[\%Ti]:[\%C] > 4$  ratio in order to eliminate their possible destruction and ensure total carbon binding. References 13: 12 Russian, 1 Western; figures 4; tables 2.

#### Peculiarities of Forming Wear Resistant Coats by Electric Contact Surface Caking of Cast Iron Powder

917D0069B Moscow IZVESTIYA VYSSHIKH  
UCHEBNYKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 9, Sep 90 pp 67-69

[Article by A. M. Tsun, M. V. Chukin, V. S. Adamechuk, V. N. Timazhev; Magnitogorsk Mining and Metallurgy Institute]

UDC 621.793

[Abstract] The possibility of using a broad range of materials in the course of electric contact surface caking enabled the authors to use waste and byproducts of shot-blasting of metallurgical equipment parts and tools

by iron shot as wear resistant coat material. The character of reduced iron shot is determined by the content of a certain particle size fraction in the total volume of spent cast iron powder. A standard mesh analysis technique pursuant to GOST 18318-73 was used in the study. The results show that it is possible to use powders produced from byproducts of shot blasting of plastic metal working parts and tools for electric contact surface caking on products in order to restore their worn out surfaces and supply them with good performance properties. It is shown that the low cost of the powder used, the simplicity of the surface caking process, and the high level of resulting cast iron layer properties make this method suitable for commercial implementation at the country's enterprises. References 2; figures 2; tables 2.

#### **On Thermal Analysis of Countercurrent Flow Blast Furnace Scrubbers**

917D0068A Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 90 pp 3-4

[Article by V. V. Kuklinskiy, V. G. Ryzhkov; Zaporozhye Industrial Institute]

UDC 669.162.275.3

[Abstract] A counterflow evaporative-condensation scrubber in which the heat transfer surface is formed by the sprinkling fluid drops and the behavior of media temperatures in it are described. It is shown that the heat transfer agent flow diagram in the counterflow blast furnace scrubber is equivalent to that of a heat exchanger with an intermediate heat transfer agent loop where the temperature head is lower than that of counterflow, making it easier to analyze the heat balance in the scrubber. Based on an analysis of published data on evaporative-condensation scrubbers, the conclusion is drawn these data were obtained on an assumption of self-similarity of heat transfer factors. Empirical equations are suggested for designing countercurrent flow blast furnace scrubbers which are adequately consistent with data obtained in tests of these devices. References 8; figures 1; tables 2.

#### **Role of Carbon in Iron Reduction**

917D0068B Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 90 pp 5-7

[Article by S. M. Tleugabulov, A. A. Shidlovskiy, S. D. Uryupin; Karaganda Integrated Iron and Steel Works Continuing Education College]

UDC 669.162.28

[Abstract] Earlier descriptions of carbon transformations in a blast furnace allowing for its rate of consumption as both a reducing agent and a source of thermal energy are

summarized. It is shown that the kinetics of iron reduction by carbon in the solid phase largely depend on the burden fraction size and system temperature. The gas composition over the burden mixture with coke is stabilized under the effect of two concurrent reactions: iron reduction from the corresponding oxide and carbon monoxide regeneration. Due to the slow process development, these reactions become equilibrated. As the sinter particle size increases to over 5 mm at 100-1100°C, the second reactions begins to dominate the gas composition. As the sinter fraction size decreases to below 5 mm and the temperature increases, the iron reduction by carbon with the formation of a CO+CO<sub>2</sub> gas mixture which is close to an equilibrium over the corresponding oxide begins to dominate the gas composition. References 6; figures 2; tables 2.

#### **Peculiarities of Gas Behavior During Steel Smelting in High-Output Electric Furnaces**

917D0068C Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 90 pp 20-25

[Article by G. O. Neygebauer, V. I. Dmitriyenko, M. B. Orzhekh, G. L. Borshchevskaya; Siberian Metallurgy Institute]

UDC 669.187.25:669.785

[Abstract] Gas behavior dynamics in the metal during the smelting of structural and tool steel from a fresh charge in the DSP-100N3A furnace with water-cooled walls and hearth is examined. It is shown that peculiar design features of the high-output electric furnace and the characteristic steel smelting technology make it possible to attain relatively low hydrogen and nitrogen concentrations in the metal by the start of the charge melting; these concentrations change little during the oxidation period. Consequently, there is no need to degas the metal in this case. It is shown that the volume and rate of metal decarburization during this smelting period should be determined solely by the conditions of other process tasks, such as diffusion annealing of the pool, removal of slagging impurities, and metal heating. References 5; figures 6; tables 1.

#### **Control of Converter Pool Decarburization by Thermodynamic State Variables of Effluent Gas: Discussion**

917D0068D Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 90 pp 87-89

[Article by V. S. Bogushevskiy, N. A. Sorokin, I. L. Ligotskiy, N. S. Tserkovnitskiy; Kiev Automation Institute]

UDC 669.184.244.66:658.012.011.56

[Abstract] Control of converter smelting by the effluent gas parameters, particularly its thermodynamic state variables, is discussed. The effluent gas pressure and temperature in the converter gas cooler (OKG) gas duct and acoustic properties of the blast are used as such variables. In determining the relationships between the variables, the authors limited themselves to a qualitative analysis of curves and to considering the outside correspondence between the mean level of the variables under study and an analysis of the paired correlation between the realizations. Steady-state cross-correlated functions characterizing the linear relationship between curves at various time shifts are plotted. It is shown that the use of correlations between the unknown converter process parameters and thermodynamic variables of the effluent gas in the form of conjugate relations is flawed since it leads to considerable errors in some smeltings. The use of thermodynamic relations which connect the effluent gas parameters makes it possible to control the pool decarburization rate and the mass fraction of carbon being oxidized to monoxide in the converter cavity. References 5.

**Intensification of Oxidation and Mass Transfer Processes in Converter Pool Under Effect of Pulsing Oxygen Jet**

917D0067B Moscow IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 7, Jul 90 pp 21-23

[Article by A. N. Kapranov, A. V. Yavovskiy, G. A. Tarnovskiy, G. V. Shebelykin, N. M. Savina; Moscow Steel and Alloys Institute]

UDC 669.184.046.54:669.74

[Abstract] Induced vibrations which under certain conditions develop into an undulatory molten metal motion under the effect of a pulsing oxygen blast on the converter pool and the related accelerated lime dissolution in the molten slag are addressed. The mass transfer intensification during the undulatory melt motion caused by the pulsing oxygen jet is attributed to an increase in the total interface area due to the wave formation, eddy motion in the gaseous and liquid phases, the presence of intensive convective mass flows, and the total mixing in the wave troughs. It is shown that the rate of oxygen and carbon oxidation increases during the pulsing oxygen blow; the blast efficiency increases under certain blast pressures which are specific to each oxidant and, likewise, the spectrum of generated pulsation frequencies. S. I. Zhigach and V. Ye. Nikolskiy participated in the study. References 4; figures 2; tables 1.

**Characteristics of Interface Behavior Under Conditions of Developed Eddy Melt Flow During Electroslag Processes**

917D0067C Moscow IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 7, Jul 90 pp 34-36

[Article by S. Yu. Andriyenko, Materials Science Institute at the Ukrainian Academy of Sciences]

UDC 621.791.793

[Abstract] The progress of physicochemical, thermal, and crystallization processes occurring during the electroslag remelting of consumable electrodes which largely depends on the structure and intensity of the electric eddy flow (EVT) in the slag and metal pools is considered. Special attention is focused on studying the slag/metal and molten metal pool/solid metal interface behavior. A physical model made as a copper vessel placed in a water-cooled housing electrically insulated from it was examined. The flat copper vessel bottom simulated the slag/metal pool interface (GShM) and mercury simulated the slag and metal pool medium. It is shown that under the conditions of electroslag processes, the presence of a developed melt EVT in the slag and metal pools facilitates the redistribution of hydrodynamic pressure on the slag/metal pool and molten metal pool/solid metal interfaces and leads to a change on the interface shape. References 5; figures 3; tables 1.

**Solution Algorithm for Axisymmetric Plastic Metal Working Problems**

917D0067D Moscow IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 7, Jul 90 pp 41-44

[Article by Yu. G. Gulyayev, V. M. Druyan, S. A. Chukmasov, G. P. Kostizhev, O. I. Lev; Dnepropetrovsk Metallurgy Institute]

UDC 621.777.0

[Abstract] An algorithm used for realizing the solution of axisymmetric problems is considered and its flow chart is cited. The initial approximating functional sequence which describes the flow rate along the symmetry axis is selected so as to ensure that the boundary value conditions are met for axial and radial coordinates. Kinematic boundary conditions which characterize the constraints on the flow rate in real processes are determined. An example of practical realization of the technique is considered for solving the problem of upsetting a cylindrical sample with a given radius and height by absolutely rough slabs (without a contact surface slip) each of which moves at a given velocity is cited and the complex of boundary conditions which the solution must satisfy is considered. It is shown that in solving axisymmetric



plastic metal working problems by the proposed algorithm, one of the two equations of motion is identically satisfied. References 3; figures 3.

#### **Kinematically Feasible Velocity Profiles During Axisymmetric Straining**

917D0067E Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 90 pp 44-46

[Article by M. Ya. Brovman, Scientific Production Association of the Scientific Research and Design Technology Institute of Mechanical Engineering]

UDC 621.771

[Abstract] The possibility of extending kinematically feasible velocity fields with rigid zones which are often used for estimating the upper bound of plane deformation to the case of axisymmetric straining is examined. Formulas are derived for the shear and forming power. Analytical results were used at the NIPTmash to develop a new forging machine for making pipe with reinforced ends. It is shown that the formulas for the axisymmetric straining force and power can be used for designing the broach and forging machine for cylindrical blanks. Implementation of the new forging machine at the Ukruglegeologiya production association made it possible to produce high-quality pipe and resulted in an annual saving of 320,000 rubles. References 4; 3 Russian, 1 Western; figures 2.

#### **Determining Contact Pressures During Transverse Extrusion in Horizontally Split Die**

917D0067F Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 90 pp 52-54

[Article by I. S. Aliyev, A. V. Satonin, O. K. Savchenko, Kramatorsk Industrial Institute]

UDC 621.777.4

[Abstract] Transverse extrusion in split dies used for making complex forgings shaped as rods with side tags or flanges and the force necessary for opening the horizontally split dies are considered. Contact stresses on the transition section between the rod and the tag and the die flange bevel are analyzed by the slip line method while the task is reduced to a plane problem. Slide line fields are plotted graphically and the extrusion of tags with a two-sided feed in a rough die with a given bevel angle is considered. As a result, computational relationships are derived for determining the disjoining pressure of a horizontally split die with conical transition bevels which take into account the effect of relative dimensions of the extruded tag of flange, the transition bevel, and contact friction conditions during the transverse extrusion. References 4; figures 3.

#### **Optimization of Gasostatic Molding of Box-Shaped Products From Superductile Material**

917D0067G Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 90 pp 57-59

[Article by A. R. Tayupov, A. A. Kruglov, V. G. Ryzhkov, V. K. Berdin; Institute of Superductility of Metals at the USSR Academy of Sciences]

UDC 539.374

[Abstract] The advantages of gasostatic molding of sheet metal in the superplastic deformation state, particularly the possibility of producing a complex-shaped part during one forming operation, the relatively low cost of the forming equipment, and the possibility of automating the process by using computers are considered. The superductile molding's sensitivity to the range of molding rates is addressed and the problem of ensuring the necessary rate forming range by defining a certain gas pressure behavior law is considered. A mathematical model is developed for deriving the optimal process control law. The finite elements method developed on the basis of the Sim-2D software package is used for modeling; the simulation software algorithm is realized on the Labtam-3815 computer in the Fortran-77 language; the results are displayed with the help of computer graphics devices. The proposed technique for optimizing the process of gasostatic molding of box-like products makes it possible to determine the dependence of the gas pressure on the time which ensures deformation in the superductile state. References 4; 3 Russian, 1 Western; figures 3.

#### **Characteristics of Recrystallization Development in Cold Worked Steel During Laser Treatment**

917D0067H Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 7, Jul 90 pp 74-77

[Article by S. I. Gubenko, V. N. Varavka, Dnepropetrovsk Metallurgy Institute]

UDC 669.14:621.9.048

[Abstract] The use of laser treatment for surface hardening of metals and alloys is addressed. The hardening effect is achieved by high-temperature working, martensite conversion with the formation of ultrafine martensite, the dissolution of carbides and nonmetallic inclusions and the saturation of their component matrix, microchemical inhomogeneity, an increase in the number of crystal structure defects, and plastic shear. An attempt is made to separate the effects of each individual factor in order to understand the nature of laser hardening. To this end, recrystallization of cold-rolled low carbon steels during laser treatment is considered. Cold-rolled sheet steels 08kp, 08Yu, 08Kh18N10T, and 3405 EKhas were used in experiments; the steel structure in

the laser irradiation zone was examined under a Tesla electron microscope and a Neophot-21 optical microscope. It is shown that during the laser treatment of cold-rolled steels with different compositions and crystal structures rolled at the same degree of straining (60-70%), a primary dynamic recrystallization occurs; it is characterized by a substructural heredity, a tenfold increase in the dislocation density, and the appearance of a columnar grain structure and crystallographic texture. References 14; figures 3.

**Mechanism of Pore Formation During Diffusion Silicon Saturation of Fe-C Alloys in Corrosive Medium**

917D0067I Moscow IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 7, Jul 90 pp 82-84

[Article by Ya. D. Kogan, I. Ya. Kanovskiy, I. D. Udovitskiy; Moscow Automotive Highway Institute]

UDC 621.785.5

[Abstract] Two models of the effect of the saturating medium on the development of porosity during the chemical heat treatment (KhTO) are proposed and experimentally and thermodynamically substantiated. Diffusion saturation with powders was conducted in the presence of chloride or fluoride activators; steels 20Kh, 45, U8, and U12 were treated for 2-4 h.  $\text{CuCl}_2$  (1-3% by mass) and  $\text{Na}_2\text{SiF}_6$  (0.5-2.0% by mass) activators were used. The mechanism of pore formation during the diffusive silicon saturation of iron-carbon alloys is examined. It is shown that the porosity morphology in the layer can be controlled by using activators and regulating the saturating medium activity. This will make it possible to produce coats with diverse physical and mechanical properties as well as develop composite layers on steel. References 13: 12 Russian, 1 Western; figures 1.

**Increasing Corrosion Resistance of Gas Turbine Plant Parts**

917D0067J Moscow IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 7, Jul 90 pp 86-88

[Article by Ye. P. Ponomarenko, V. N. Truskov, A. A. Rabinovich, V. V. Kononov, A. G. Andriyenko, A. P. Khvalin; Zaporozhye Mechanical Engineering Institute]

UDC 621.799

[Abstract] The use of protective coats for increasing the resistance of high-temperature alloys (ZhS) to oxysulfide corrosion, particularly slip-based  $\text{AlSiMe}$  where  $\text{Me}$  is chromium and/or titanium as well as molybdenum and niobium is considered; in addition to traditional processes, the processes of high-temperature diffusion formation of slip coats whereby partial ZhS fusing and, consequently, curing or surface defects (pores and microcracks) are possible are examined. Cast slabs or cast gas turbine plant (GTU) blades from the EP539LM alloy, Inconel-738LC, or its domestic clone ZMI-3U ( $\text{KhN64VMKYuT}$ ) were used; various types of protective coats were applied on them. The coat structure was examined under a Neophot-2 microscope or a Stereoscan analyzer microscope. The microhardness was measured by a PMT-5 instrument and the phase composition and lattice constants of the coats were determined by a DRON-1 diffractometer in copper's  $K_\alpha$  radiation; the chemical composition was measured in a Cameca MS46 unit while the corrosion resistance was estimated by the depth and character of coat failure in a salt melt and in a gas dynamic bench using combustion products of the TGVK "heavy" fuel. It is shown that along with the electron beam  $\text{CoCrAlY}$  coat which has proven itself well, the use of the  $\text{AlSiCrTi}$  slip composition is effective in inside cavities for increasing the corrosion resistance of GTU parts. References 6; figures 2; tables 2.

**Conditions for Attaining Steady and Requisite Molten Metal Rate During Teeming From Tilting Ladle**

917D0067K Moscow IZVESTIYA VYSSHIKH  
UCHEBNIKH ZAVEDENIY: CHERNAYA  
METALLURGIYA in Russian No 7, Jul 90 pp 91-92

[Article by V. G. Kuznetsov, S. P. Beltsov, G. A. Kozyakova, V. V. Nazaratin, M. A. Timofeyev; Central Scientific Research Institute of Mechanical Engineering Technology]

UDC 621.746.32

[Abstract] Basic principles of an analysis technique making it possible to establish the rate of turn of barrel-type and teapot spout ladles which ensures a constant and requisite molten metal flow rate from the ladle are presented. Differential equations which define the elementary volume efflux time are derived for both types of ladles. In solving the equations, the dependence of the molten metal surface area on the metal level height or the ladle tilt angle is taken into account. The proposed technique makes it possible to develop computer-aided actuators which ensure a constant and requisite flow rate during the entire casting period. References 1; figures 3.

### Effect of Steel Part Hardness on Adhesion Strength of Detonation-Gas Coats

917D0074A Moscow SVAROCHNOYE

PROIZVODSTVO in Russian No 10, Oct 90 pp 20-23

[Article by Yu. A. Kharlamov, M. I. Livshits, V. V. Omelchenko; Voroshilovgrad Mechanical Engineering Institute and Zaporozhye Production Association Motorostrel]

UDC 621.793.7:621.791.052:539.4

[Abstract] The effect of the steel parts' base hardness on the adhesion strength of coats applied on them by the detonation gas method was examined experimentally in a UDK-1 all-purpose detonation-gas complex. The adhesion strength was measured in pin samples made from steel 20 (as shipped), steel 45 (martempered to 35-39 HRC), and low alloyed tool steel 9KhS (martempered to HRC 54-58 HRC). The sputtered sample surface was polished and subjected to an abrasive jet machining by synthetic corundum with a 40  $\mu$ m grain size. The samples' hardness was measured afterwards. Ni-Cr alloy PKh20N80 powder (with 20% Cr and 80% Ni) and conglomerated VK18S (WC and 18% Ni) and KKhN15S ( $Cr_3C_2$  with 15% Ni) powders were used. The results show that chromium carbide has the worst properties of all the materials tested. It is recommended that the parts preheating temperature be increased, the sputtered particles be superheated, and the velocity of their collision with the part surface be increased in order to obtain a detonation-gas coat with a uniform adhesion strength. Research data also demonstrate that there is no need to increase the parts surface hardness too much; if it is necessary to ensure a high surface hardness, one should increase the irregularity height and microrelief profile valley depth or use thin sublayers from plastic metals and alloys. It is recommended that optimal sputtered particle velocities and temperatures be calculated in order to lower expenditures for experimental development operations. References 9; figures 3; tables 4.

### Zone Heat Treatment of Welded Joints of High Strength Steels by Electron Beam Immediately After Electron Beam Welding in Vacuum

917D0074B Moscow SVAROCHNOYE

PROIZVODSTVO in Russian No 10, Oct 90 pp 23-24

[Article by N. N. Yevgrafov, Yu. T. Lysenkov, Ye. M. Feoktistova, A. V. Gerasimenko, A. A. Blokhin]

UDC 621.791.052:539.4.014

[Abstract] The use of multifunction electron beam treatment equipment which makes it possible to weld and then heat treat welded joints directly in the vacuum welding chamber is considered. Experimental investigations of electron beam welding (ELS) and subsequent zone heat treatment (ZTO) by electron beam in a vacuum were carried out on 300x200x20 mm samples.

The ZTO was conducted immediately after ELS by moving the product relative to the heat source. A 200x40 mm rectangular heating zone was used; the product was moved at a 4 m/h rate. To estimate the ZTO quality, residual stresses and hydrogen content in the welded joint were measured. The temperature pattern in the weld plane was calculated on an assumption of a rectangular surface heating zone and a uniform energy distribution in the heating spot. The results show that zone heat treatment by electron beam in a vacuum is an efficient means of reducing and redistributing residual stresses and hydrogen concentration in welded joints of high strength steel made by ELS. A heating to 900°C makes it possible to decrease the maximum residual tensile stress from 675 to 100 MPa and reduce the maximum hydrogen content from 1.65 to 0.8 ml/100 g. References 2; figures 4.

### Plasma Spraying of Wear-Resistant Coatings on Iron and Steel Shaft-Type Parts

917D0094A Moscow SVAROCHNOYE

PROIZVODSTVO in Russian No 11, Nov 90 pp 5-7

[Abstract of article by R. Ye. Vodzinskiy, G. A. Pavliychuk, A. B. Koshevetskiy (Institute of Electric Welding imeni Ye. O. Paton), V. A. Kakuyevitskiy (Aviotransport Production Association)]

UDC 621.793.74

[Abstract] Researchers have developed a technology for plasma spraying wear-resistant coatings onto iron and steel shafts and similar parts, especially the crankshaft main journals and crankpins of various automobile engines. The plasma-forming electric arc is struck between an internal core cathode and the wire (or rod) feedstock, which serves as an external anode intersecting the tip of the plasma flame at a 90° angle. (The point of intersection is outside the spray gun.) The arc gas is a mixture of air and compressed inert gas. The coatings are applied in layers 0.005 to 0.1 mm thick. During spraying, the workpiece is rotated, and each layer prepped by a wire brush rotating in the same direction as the workpiece. The UN-126 plasma spray station, the UN-127 and UPDN-002 automated plasma spray stations, and the Plamya-5M plasma spray gun were developed specifically for this process, which uses 30 to 45% less electricity per kg of feedstock than comparable systems using powder stock. Coatings up to 15 to 20 mm can be applied without danger of coating degradation. Coating bond strength is from 40-55 MPa. Coating density for atomized 65G wire is 93-96% of theoretical, and 98% when 04Kh20N11MZDT wire is used. Coating porosity ranges from 1-4%. Results of tests performed on main journal and crankpin specimens cut from worn crankshafts refaced with 65G wire showed considerable improvement in the fatigue limit. When tested under industrial conditions, the Plamya-5M plasma spray gun had a service life of 800 to 900 hours before preventive maintenance was required, with minimal wear to gun



components at arc voltages ranging from 12 to 30.6 kV. The new process represents an improvement in efficiency and versatility, reduces thermal stress to the gun nozzle, and provides for flexibility in coating characteristics. Figures 3; references 7; Russian.

**Utilizing Low-Frequency Current To Heat Ship Diesel Engine Slide Bearings When Surfacing Them With Babbit Metal**

917D0094B Moscow SVAROCHNOYE  
PROIZVODSTVO in Russian No 11, Nov 90 pp 27-28

[Article by Yu. I. and V. Yu. Veslopolov; Olenogorsk Power-Driven Machinery Plant (Murmansk oblast)]

UDC 621.791.927.7:669.018.25

[Abstract] A new technology was developed for employing low-frequency current to heat slide bearings when surfacing them with babbitt metal. The bearings are simultaneously rotated at about 300 rpm and heated until the anti-friction layer is completely melted, after which rotational frequency is selected according to a formula. The inductor is connected to clamps on the induction voltage regulator of an LPZ-67V induction unit with a current frequency of 70 kHz. The wetting of the zinc coating of the electrogalvanized bearings promotes better fusion of the babbitt layer with the steel substrate. Also, galvanizing instead of tinning saves tin, which is costly and in short supply. Slide bearings surfaced in this manner with B83 babbitt were subjected to extensive performance tests in NVD-24 ship diesel engines. Their average service life was 25% higher than that of conventionally made bearings. Basic process parameters are current frequency, heating time, inductor size and shape (internal diameter, length, and number of windings) and electrical specifications for current and clamp potential. Heating time is the most difficult parameter to set and is calculated using differential equations. A computer program for heating time was written and run on an Iskra computer with output printout capability. Heating time data were used to construct heating time vs inductor current curves.

**Results of Adopting Air Plasma Cutting of Thin Sheet Steel**

917D0094C Moscow SVAROCHNOYE  
PROIZVODSTVO in Russian No 11, Nov 90 pp 30-31

[Article by Yu. P. Tuz, S. G. Sumrin, Z. I. Fridkis; Uralmash Production Association]

UDC 621.791.945

[Abstract] A technology utilizing plasma torches for machine cutting low-carbon sheet steel 1 to 6 mm thick has been introduced to replace mechanized cutting with an oxyfuel torch. AVPR-3 and Dnepr cutting stations equipped with PVR-10 plasma torches are the basic

equipment. Imported and specially modified (by modernizing some components and developing new ones) KT-720 numerically controlled flame-cutting machines are also used for cutting speeds up to 100 mm/s. (Specifications for this machine are provided.) The cabinet-housed power supply of the cutting stations is based on a VD-301 welding rectifier. The plasma torches are made by the Institute of Electric Welding imeni Ye. O. Paton. They are water-cooled, and their electrodes are resistant to oxidizing media and have a service life of up to 300 operations. The stations are also equipped with a cable and hose system, a device for adjusting torch position, and a ventilated storage area. The torch position adjusting device utilizes an electronic control system to adjust the tracking position and height of the torch. Adoption of this technology along with computer programs for maximizing the number of workpieces cut from a single sheet resulted in increased productivity, improved cutting quality, and annual savings of 20 thousand rubles.

**Microstructure of Ni-Cr-B-Si Alloys Deposited By Laser Surfacing**

917D0094D Moscow SVAROCHNOYE  
PROIZVODSTVO in Russian No 11, Nov 90 pp 34-36

[Article by A. N. Safonov, Scientific Research Center for Industrial Lasers, Shatura, Moscow oblast]

UDC 621.791.927.2:621.373.826

[Abstract] The microstructure of Ni-Cr-B-Si alloys deposited by laser surfacing was studied. PG-SR2, PG-SR3, PG-SR4, SNGN35, and SNGN45 powder alloys were used to hard-face ST3, U8, and 40Kh10S2M steel and SCh24 iron substrates. A continuous 1 kV CO<sub>2</sub> laser beam or low-frequency current was used as the heat source. The alloys were also plasma sprayed onto the substrates. After the surfacing metal was deposited, it was glazed with an inert gas plasma. The microstructure of the surfacing metal was studied on optical and scanning electron microscopes, and x-ray diffraction analysis was performed on DRON-2 and DRON-3 diffractometers. The diffractograms revealed the presence of the following phases: nickel-based  $\gamma$ -solid solution, a  $\gamma$ -Ni<sub>3</sub>B twin eutectic, and Cr<sub>23</sub>C<sub>6</sub>, Cr<sub>3</sub>C<sub>2</sub>, and Cr<sub>7</sub>C<sub>3</sub> carbides and CrB and Cr<sub>2</sub>B borides. The microstructure of the surfacing metal deposited using a laser beam as the heat source differed substantially from that of the metal deposited using the other two methods. The most notable feature is the presence of  $\gamma$ -solid solution dendrites oriented towards the surface of the deposited metal. There was a nearly 10-fold decrease in microstructural parameters such as carbide phase and solid solution cell size and in the interdendrite parameter, and microhardness evened out noticeably. Laser surfacing is accompanied by substantial saturation of the solid phase with the alloying elements and by an increase in the degree of metastability of the carbide phases. Figure 2, tables 2; references 5: 4 Russian, 1 Western.



### Causes of Coke Overexpenditure in USSR's Blast Furnaces

917D0091A Dnepropetrovsk  
METALLURGICHESKAYA I GORNORUDNAYA  
PROMYSHLENNOST:  
NAUCHNO-TEKHNICHESKIY I  
PROIZVODSTVENNYY SBORNIK in Russian No  
3(157), Jul-Sep 90 pp 1-3

[Article by N. K. Leonidov, Ya. M. Obodan, M. B. Kutner; All-Union Institute of Scientific and Engineering Information at the USSR State Committee of Science and Engineering and the USSR Academy of Sciences, Ferrous Metallurgy Institute, and Ukrprommez]

UDC 669.162.283.16.003.1

[Abstract] Processes occurring in blast furnaces and blast furnace coke are examined and economic aspects of the smelting process are considered. An analysis of the adjusted specific coke consumption in the USSR and Japan shows that in the USSR the rate is considerably higher. A comparison of consumption data shows that the coke overconsumption in the USSR is primarily caused by an excess blast enrichment with oxygen which increase direct reduction due to an increase in the tuyere gas temperature and the related increase in the silicon content in the pig iron; in the USSR the figure is two- to threefold higher than in Japan. Furthermore, the degree of indirect iron oxide reduction also decreases noticeably. These factors lead to a corresponding overconsumption of coke and increase the cast iron and steel cost. Japan's advanced methods as well as positive results attained at imeni G. I. Petrovsky plant (i.e., blast enrichment with nitrogen) show that a transition of USSR blast furnaces to an efficient smelting technology in the shortest time and improvements in the charge quality should raise industry indicators to world level; in so doing, tuyere gas composition can be maintained at the minimum possible level. References 7; tables 3.

### Once Again About Blast Furnace Height

917D0091B Dnepropetrovsk  
METALLURGICHESKAYA I GORNORUDNAYA  
PROMYSHLENNOST:  
NAUCHNO-TEKHNICHESKIY I  
PROIZVODSTVENNYY SBORNIK in Russian No  
3(157), Jul-Sep 90 pp 4-6

[Article by V. G. Druzhkov, Magnitogorsk Mining and Metallurgy Institute]

UDC 669.162.211.4

[Abstract] A reply to V. L. Pokryshkin's and N. K. Leonidov's article On Reducing the Height of Blast

Furnaces published in *Metallurgicheskaya i Gornorudnaya Promyshlennost* No. 2 1989, pp. 8-10. The issues involved in calculating the height of blast furnaces and the stack slope are considered. The author compares the height of blast furnaces in the USSR and USA and Japan; data on blast furnaces at USS, Republic Steel, Great Lakes Steel, Lone Star Steel, and Kawasaki Steel manufactured by Ferfield, South Chicago, River Rouge, Cleveland, and Mizushima are summarized. The author asserts that his formulation of the problem of the expediency of decreasing the height of blast furnaces under construction as well as during overhaul is well-argued. Ratios of blast furnace height to diameter are analyzed and limits of these ratios are set; it is shown that the idea to decrease the height/diameter ratio is scientifically sound, yet it is indicated that it is expedient to attain such a decrease without reaching the limiting value below which the axial zone of low-mobility materials in the furnace begins to increase rapidly while the zone with a relatively uniform charge tailing in the stack degenerates. References 8: 4 Russian; 4 Western; figures 1; tables 2.

### Development of Advanced Heat Treatment Technology Ensuring Quality Improvement of Milling Balls With 60 and 80 mm Diameter

917D0091C Dnepropetrovsk  
METALLURGICHESKAYA I GORNORUDNAYA  
PROMYSHLENNOST:  
NAUCHNO-TEKHNICHESKIY I  
PROIZVODSTVENNYY SBORNIK in Russian No  
3(157), Jul-Sep 90 pp 28-30

[Article by V. A. Grin, A. F. Siukhin, T. P. Chaykovskaya, Zh. V. Bashkatova, I. L. Levchenko; Dnepropetrovsk Metallurgy Institute and UkrNIIImet]

UDC 621.775.26:621.785.001.5

[Abstract] Production of metal balls for ball mills by the rolling method and their heat treatment are examined and existing technologies are compared. Optimal process parameters for heat treatment hardening of milling balls with a 60 and 80 mm diameter in a drum unit produced by the Azovstal Integrated Iron and Steel Works are determined. These parameters increase the metal surface hardness level. The issue of the expediency of implementing the drum hardening unit in the SPSH-80 rolling mill is discussed. It is shown that a final implementation decision calls for conducting pilot and commercial studies allowing for the specific rolling mill output. The proposed method will make it possible to make category P balls pursuant to GOST 7524-89 with a surface hardness of HB 451-550 instead of the currently made category N balls with a surface hardness of HB 450. References 7; figures 3; tables 2.

**Mathematical Model of Turbulent Metal Flow Under Vacuum in Ladle**

917D0092A Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 11, Nov 90 pp 29-31

[Article by N. I. Ovchinnikov, V. A. Shcherbakov, Moscow Steel and Alloys Institute]

UDC 669.046

[Abstract] A continuation of studies published in *Izvestiya vysshikh uchebnykh zavedeniy: Chernaya metallurgiya* No. 7 1990, pp. 37-39 and No. 3 1986, pp. 35-39. The results of the aforementioned publications are extended to the case of a nonsteady flow of molten metal in the ladle. As a result, a nonsteady model of the turbulent flow of molten metal in a vacuum in the ladle is developed. The character of transient processes in the ladle hydrodynamics is examined. It is established that the flow develops according to the law of steady-state motion. The model makes it possible to calculate velocity profiles (lines of flow) and the degree of molten metal turbulization as a function of the unit's operating conditions. It is expected that the calculation results will be used for making a comparative analysis of the efficacy of various method of metal stirring in a vacuum. The model was identified under commercial conditions in a 150 t unit for ladle refining and ladle degassing by comparing the actual parameters to analytical results. References 5; figures 2.

**Optimal Scheduling of Steel-Making Plant With Continuous Casting of Castings**

917D0092B Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 11, Nov 90 pp 92-94

[Article by V. M. Buynitskaya, V. I. Grankovskiy, Zaporozhye Industrial Institute]

UDC 669.184:658.513.5

[Abstract] The problem of optimal scheduling of the steel-making plant operations with continuous casting machines (MNLZ) and ladle treatment units (UVO) is considered. The problem is presented in a combinatorial formulation and is solved by the shortest path method in order to determine the MNLZ series size and mold type and select a sequence of smelting of various brands of steel so as to ensure continuous casting of smelting series of the same brand with a minimum total ladle waiting time and minimize energy outlays for maintaining the necessary metal temperature before and during the casting. It is shown that under existing conditions the optimal on-line version of the entire plant equipment operation calls for using computers. In the framework of a computer-assisted steel-making plant with on-line access to data on the state of units at the start of the decision-making process, it is possible to calculate the optimal operating schedule of plant units on-line and correct it should the situation change abruptly. It is shown that an increase in the scheduling interval, differences in the casting duration, and other factors complicate the optimal design procedure. References 7; figures 1; tables 3.

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